The Impact of Alcohol Consumption ON Hospital Treatment Cost and Length of Stay for Non-alcohol-related Diseases:

A retrospective cross sectional comparison of patients with alcohol-related co-morbidities and those without alcohol-related co-morbidities

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Declaration: I am hereby declaring that this thesis is a result of my own work and prepared for completion of my master programme. Previous literatures are properly recognized and cited in accordance with ethical and universally acceptable standards. The findings and interpretation of the results and omissions are solely mine.

Caliph Moumin

ABSTRACT

Background: Alcohol is a commodity which contains toxic substances like ethanol and methanol (WHO, 1994). It is a primary cause of negative health effects, and a main risk factor for many other major chronic diseases (Rehm et al., 2009; WHO, 2011b). The health and economic burden attributable to alcohol is enormous thorough the globe (Rehm et al., 2009; Rutherford and McNeill, 2009). The unknown economic losses of alcohol, because of the difficulties in estimation, could be huge and misleading if not estimated with conscious (Baumberg, 2006). The intricateness and multidimensional correlations between alcohol consumption and health problems attributable to alcohol (Rehm et al., 2010) makes such estimations even more obscure.

Objective: The objective of this study was to find whether there is higher treatment cost and longer length of hospital stay (LOS) for those with alcohol related co-morbidities than those without these co-morbidities, for the treatments of the pathologically non-alcohol-related diagnoses.

Method: Negative binomial regression model and generalized linear regression model were applied to LOS and treatment cost respectively for 8 diagnoses selected from Norwegian patient registry 2008.

Results: Patients with alcohol-related diseases had statistically significant higher treatment cost for all 8 diagnoses among males. Four diagnoses of which had longer LOS for females with alcohol-related diagnoses had also higher treatment cost amongst females. The longer LOS for erysipelas (A46), unspecified chest pain (R074), and pain localized to upper abdomen (R101) were found statistically significant for both women and men with alcohol-related diseases. In addition women with alcohol-related diagnoses had statistically significant longer LOS for unspecified asthma (J459) and acute tubule-interstitial nephritis (N10) than other women, whereas men identified as alcohol consumers were found to have longer LOS for volume depletion (E86) and other unspecified convulsion (R568) than other men.

Conclusions: Alcohol related diseases co-occur with other diseases; co-morbidity of diseases is associated with increased health care costs; the result of this study implicates that patients with alcohol related diseases had higher treatment cost with longer LOS for the treatment of the non-alcohol related diagnoses. If this is the case it would mean that economic burden of alcohol is underestimated.

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Abbreviations and Acronyms

AAF	Alcohol-attributable fractions
APC	Adult per capita alcohol consumption
CEA	cost-effectiveness analysis
DALY	Disability adjusted life years
DRG	diagnoses related groups
EMR	Eastern Mediterranean region
EU	European Union
EUOHCs	European Observatory on Health Care Systems
EUR	European region
GDP	Gross domestic product
GISAH	Global Information System on Alcohol and Health
GNP	Gross national product
IAS	Institute of Alcohol Studies
ICD-10	International disease classification code 10th Revision
LOS	Length of hospital stay
NIPH	Norwegian institute of public health
NPR	Norwegian Patient Registry
OECD	Organization for Economic Cooperation and Development
PAF	population attributable fraction
USA	United State of America
WHO	World health organization

1. Introduction

Concerns of the health, economic and social consequences attributable to alcohol are not new phenomenon; studying these consequences dates back for centuries if not since the beginning of the recorded history of alcohol consumption (Melberg, 2006; Rehm et al., 2009). But the alarming voices of these consequences of alcohol are more vivid and louder ever before. The international disease classification code known as 'ICD-10' includes the word 'alcohol' to more than 230 three-digit or four-digit codes of health problems either as their prime or partial cause (Rehm et al., 2009). This triggered parallel increased concerns about the economic and social cost of alcohol burden. Studies about the economic consequences of alcohol have been accumulated throughout the globe. Very recent ones are conducted by Schwappach et al. (2012); Stevenson et al. (2012); Scarborough et al. (2011); Popova et al. (2011).

What all these and other economic evaluation studies of alcohol related problems have in common are concerns about the increasing loss of scarce economic resources that are fully or partially associated to alcohol problems. According to the Institute of Alcohol Studies (IAS, 2007) factsheet, the social cost of alcohol in Europe is more than the welfare and security spending. Direct health care costs, productivity loss, the cost of accidents related to alcohol, the cost of welfare care for disability-adjusted-life-years (DALY) and other direct and indirect costs are attributed to alcohol consumption (Godfrey, 2004).

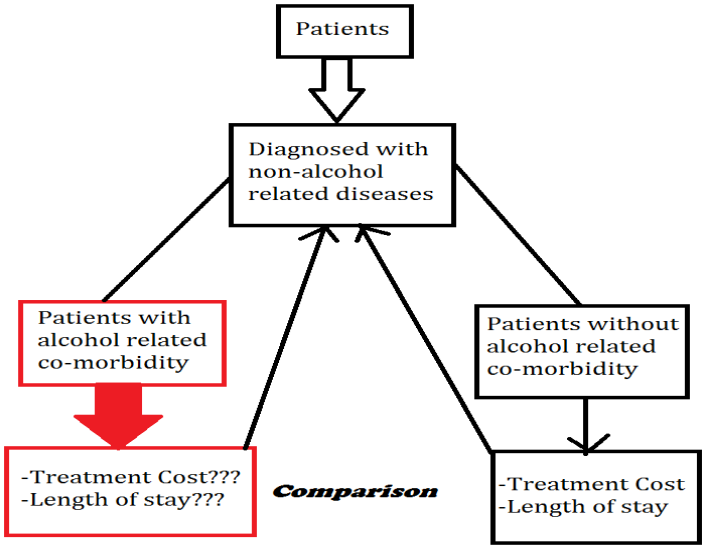
While it is worth noting the economic benefit of alcohol industry in terms of employment and its contribution to the gross domestic product(GDP), the unknown social losses of alcohol, because of the difficulties in estimating societal loss of alcohol, could outweigh these benefits if not controlled properly (Baumberg, 2006; IAS, 2007). The intricateness and multidimensional correlations between alcohol intake and health problems (Rehm et al., 2010) makes such estimations even more obscure.

Alcohol prevention policies, like alcohol taxation (one of the main and most effective policies for reducing alcohol consumption), are determined by the economic and societal cost evaluation of alcohol. Failure to reflect the true cost of alcohol in cost-benefit analysis could affect alcohol taxation, and the effectiveness of the policy. Most of the economic evaluations of alcohol consumption focus on certain illnesses, which the causal association with alcohol intake were already discovered. However, there are many other health conditions which such kind of associations are not discovered yet. Little is known about how alcohol through alcohol co-morbidity affects the cost behavior of such illnesses that are not related to alcohol. Is it

costly to treat patients with alcohol problems who were diagnosed with alcohol-related co-morbidity from other non-alcohol-related health problems? If this was the case, it would mean the societal cost of alcohol was underestimated; thus by not capturing the true cost of alcohol could lead ineffective preventive policies. In other words, undervaluing the economic loss of alcohol affects not only the results of the cost-benefit analyses, but also the policy implications of these studies to effectively reduce alcohol consumption by taxation and other preventive policies.

The objective of this study was to find whether there are treatment cost and length of hospital stay (LOS) variations between patients with alcohol-related co-morbidities and those without alcohol-related co-morbidities for the treatments of non-alcohol-related diagnoses as illustrated in figure 1.1 below. Observational retrospective data of 2008 Norwegian patient registry (NPR) were used to analyze and compare the LOS and hospital treatment costs of patients with alcohol-related problems to other patients.

Figure 1-1: Is the treatment cost and length of hospital stay different between those with alcohol co-morbidity and those without it?



Although the analysis of this study was limited to the hospital cost, yet it is an important contribution to previous studies conducted about the economic evaluation of alcohol costs and alcohol policies. This study looked at the cost of alcohol from a new perspective. The bulk economic evaluations of alcohol burden studies have contributed to understanding of how huge economic loss of alcohol burden is. However, no available studies of a broader perspective of alcohol loss by including not only the economic burden of diseases discovered association with alcohol but also the effect of alcohol and/or alcohol co-morbidity to other diseases were found. The limited knowledge about this area was what initiated this study.

1.1 Structure of the Study

The study contains seven chapters, chapter one introduces the gap and importance of this study. Chapter two extensively explains the alcohol problems both in Norway, Europe and the worldwide. Chapter three presents the previous theories of alcohol use, economic evaluations and the problem of co-morbidity. Chapter four describes the data structure and models. Chapter five presents the results and findings of the study. Chapter six presents the discussions and analysis. And brief conclusion of the study is presented in chapter seven.

1.2 Ethics

The study was based on patient record; which could be sensitive if personal information is revealed. However, personal identity was excluded from the dataset. Hypothetical identifiers were assigned to observations, and age was included in categorical form. Neither the author nor readers could identify the personal identity of the patients. Analysis was made anonymously without revealing any personal information. Moreover, the dataset was used for other studies conducted by the department of Health Economics and Management at University of Oslo.

2. Background

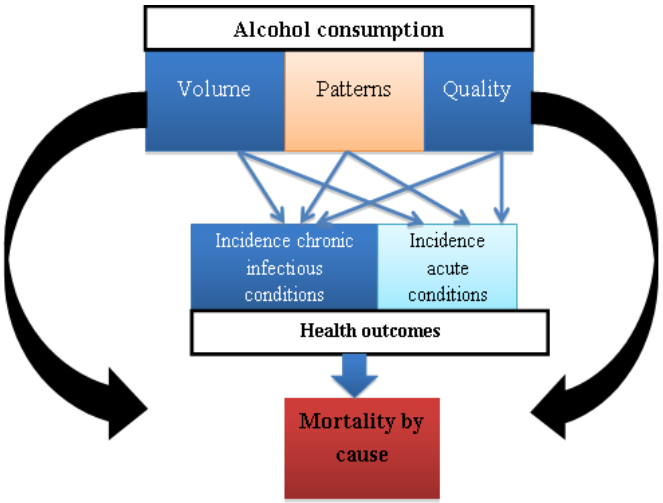
2.1 Alcohol Metabolism Process and Causation Model

Alcohol is one of the oldest and most widely consumed commodities by human beings since ancient era (Horton, 1991; Room et al., 2005). It consists of large group of organic compounds like ethanol and methanol which are toxic and endanger the health of the consumers (WHO, 1994). It is both a primary cause of negative effects like trauma, alcohol-use disorder, liver cirrhosis, and alcohol-induced pancreatitis; and it is a main risk factor for many other major chronic diseases like cancer, cardiovascular diseases (Rehm et al., 2009; WHO, 2011b). The risk of the toxic substance (ethanol) is increased by alcohol metabolism pathways; the process of extracting and absorption of alcohol from the blood.

Most alcohol metabolism happens in the liver organ, however, there are many body organs like esophagus, small intestine, veins, stomach, bowels, brain and other important organs of the body which either involve the metabolism process or the distribution of alcohol before and after metabolism process begin (Zakhari, 2006). During this metabolism process alcohol impairs the tissues of these body organs (Koop, 2006), resulting deaths and disabilities among alcohol consumers throughout the world due to large number of different medical conditions which directly or indirectly originate from this metabolism process (Zakhari, 2006). The detrimental effect of alcohol is high in the liver organ because of its main role for absorption and extraction of the toxic substances of alcohol from the body (Clemens, 2006).

The causal associations between alcohol consequences and alcohol consumption are very intricate and multidimensional (Rehm et al., 2010). The causation model shown in Figure 2-1 below (adapted from Rehm et al. (2010) illustrates how volume; pattern; and quality of alcohol consumed participate to chronic and acute health conditions. While increase in volume and pattern of drinking has positive association with alcohol related consequences, so is the low quality with high concentration of methanol and ethanol; usually home made alcohol beverages (Rehm et al., 2010; GreenFacts, 2006b). Rehm et al. (2003b) argued that alcohol consumption causes the detrimental health consequences through three intermediary means namely *intoxication*, *dependence* and *direct biological effects*. Intoxication relates to alcohol problems such traffic and other accidents, dependence relates to the problem of alcoholism and addiction, and direct biological effects are chronic health problems due to

Figure 2-1: Causation Model, Intermediary mechanisms and long-term consequences of alcohol consumption



Source: Adapted from Rehm et al. (2010)

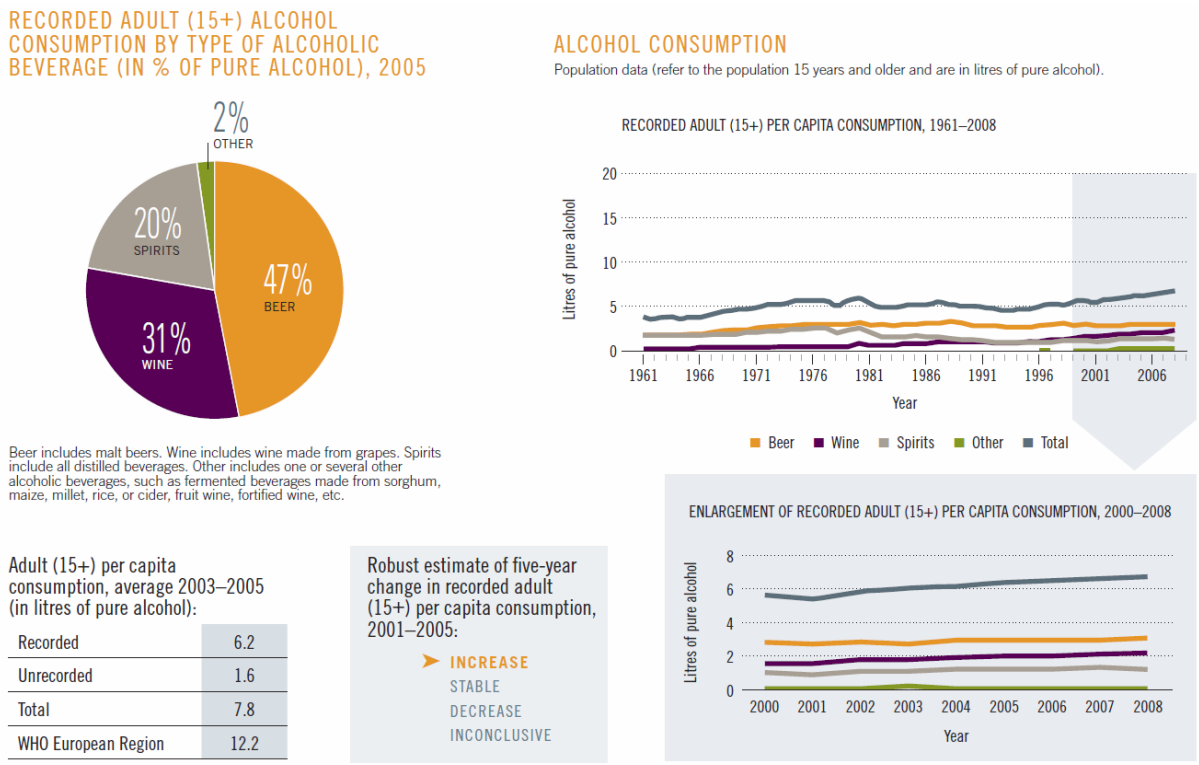
alcohol consumption (Rehm et al., 2003b). While these three intermediary mechanisms are not mutually exclusive, however such classifications are helpful for reducing the complexity problem of the relationship between alcohol consumption and its consequences. The volume, pattern and quality of alcohol beverages through these three and other intermediary mechanisms lead to negative health outcome which later results death.

2.2 Alcohol Consumption

Although alcohol is widely consumed worldwide, there are differences in drinking habits and attitudes (Bloomfield et al., 2003) as well as alcohol production process in terms of how it is produced and where it is produced (domestic or abroad). This resulted in variations of alcohol concentration. However, it is important to measure the alcohol consumption of a country with respect to other countries. This necessitates the need for common measurement which can be applied to all countries. One of the mainly used measurements is adult per capita alcohol consumption (APC), which is the per capita of pure alcohol (the ethanol) intake in liters by given adult population of above 15 years (WHO, 2011b). This common measurement helps for international comparison of the factors influencing the drinking habits as well as the political actions towards the provision of reducing alcohol consumption (Bloomfield et al., 2003). APC measurement is used to highlight the alcohol consumption of Norway versus other countries.

2.2.1 Alcohol Consumption Level in Norway

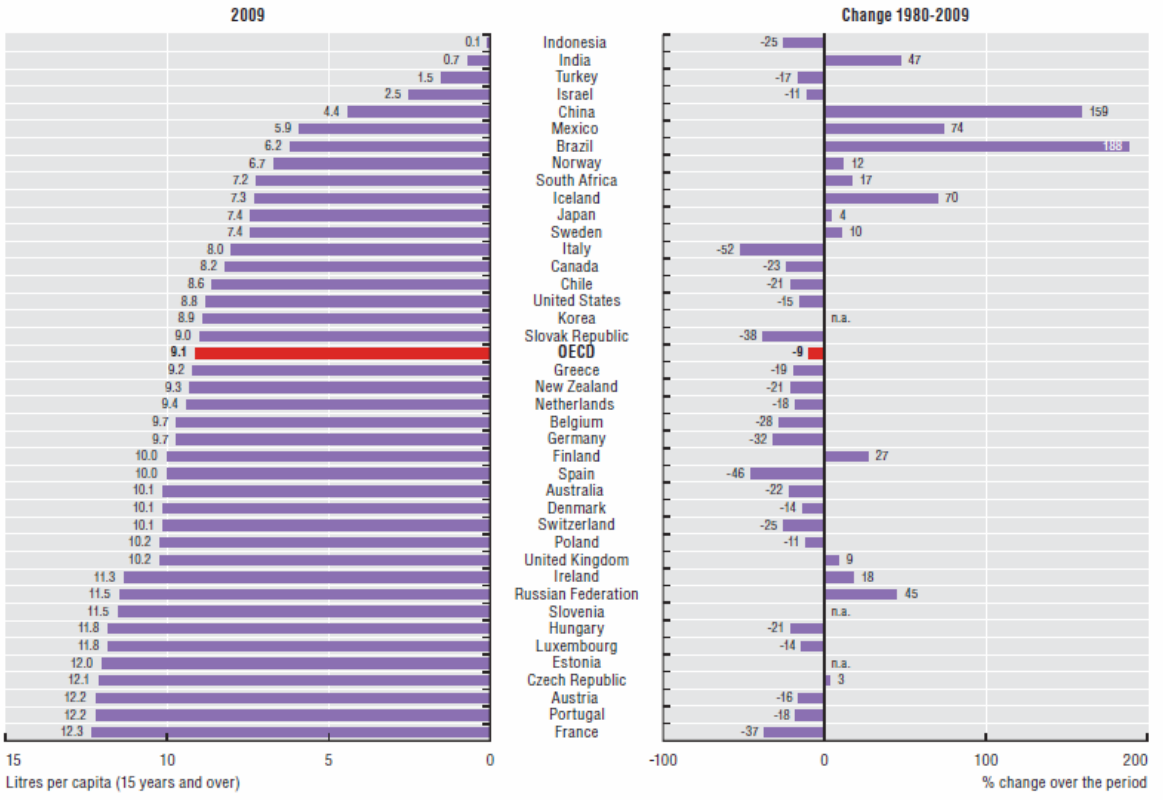
Figure 2-2: Alcohol Consumption level and Trends in Norway



Source: adapted from WHO (2011c)

Although Norway has the strictest alcohol control policy amongst the Organization for Economic Cooperation and Development (OECD) (Brand et al., 2007; WHO, 2011c); however, according to the Norwegian institute of public health (NIPH, 2010) factsheet of alcohol consumption, the consumption of alcohol has been increasing for the past four decades. The alcohol consumption trend of Norway for the past half century; and level and changes of alcohol consumption for the last four decades are presented in the figure 2.2 above (WHO, 2011c). Figure 2.3 below also indicates an increasing alcohol consumption in Norway (OECD, 2011a). The alcohol consumption in Norway, which is 6.7 litre of pure alcohol per capita of the population above 15 years, is one the lowest level of alcohol consumption in OECD countries as shown in Figure 2-3 (OECD, 2011b). But, it is also one of the few countries which had an increased alcohol consumption level between 1980 and 2009. Contrary to the 9% reduction of average alcohol consumption in OECD countries, there was 12% increase of alcohol consumption in Norway during this period. The impacts of globalization, internet, regional integration, as well as changes of income have no doubt increased the use alcohol (Rutherford and McNeill, 2009).

Figure 2-3: Alcohol consumption, population aged 15 and above, 2009 (or nearest year) and changes between 1980 and 2009



Source: Adapted from OECD (2011b)

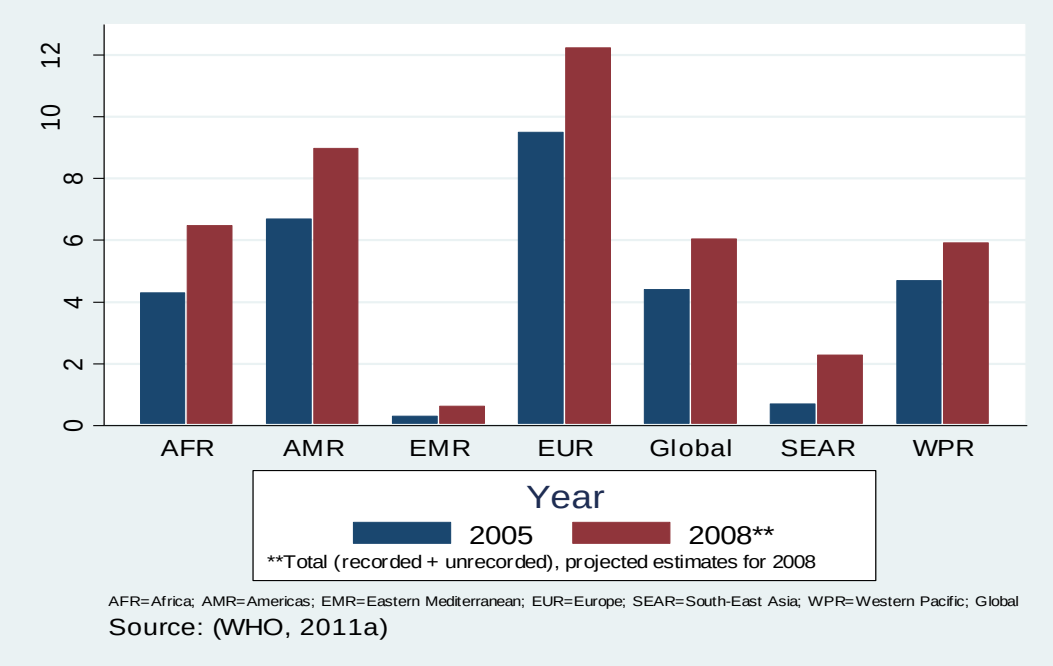
Despite the fact that alcohol consumption in Norway increased during this period, it is important to note that this increment is minimal both in terms of yearly trend and OECD country comparison as shown in figure 2.2 and figure 2.3 respectively. Even though there was decreased trend of alcohol consumption in many OECD countries, the alcohol consumption level of Norway is still much lower than most of the other OECD countries.

2.2.2 Global Alcohol Consumption

About one-third of the world's total population drinks alcohol (Greenfacts, 2006a). Even though alcohol problems' prevention policy is among the highly prioritized in public health issues (WHO, 2012), alcohol consumption is increasing globally (WHO, 2011a) as shown in the Figure 2-4 below. According to WHO (2011a) Global Information System on Alcohol and Health (GISAH), the global total adults (15+ years) per capita consumption of pure alcohol (in litres) per year (presented in Figure 2-4) for the years of 2005 and 2008 was 4.4 and 6.04, respectively. The Figure 2-4 also shows that alcohol consumption has increased between 2005 and 2008 in all regions. The Europe region (EUR) had the highest level of alcohol consumption in 2005 and 2008. However, according to WHO (2012) European Union(EU)

had a stable level of alcohol consumption in the last decade. Studies indicate high level of alcohol consumption in eastern European countries, and low level of alcohol consumption in Nordic countries (Popova et al., 2007).

Figure 2-4: Total adults (15+ years) per capita consumption of pure alcohol (in litres)



The high level of alcohol consumption in EUR is also apparent from Figure 2-3 of OECD health data where the majority of these countries are in EUR. The alcohol consumption is lowest in the Eastern Mediterranean Region (EMR), where the majority of the population are Muslim (GreenFacts, 2006b). However, according to WHO (2011b) EMR has 56.2% of homemade and illegally produced alcohol beverages of APC in 2005. This figure is the second highest next to South-East Asia which has 69.0% of illegally alcohol beverage production. The homemade and illegally produced alcohol beverages could be fatal and can cause acute death as well as disability (GreenFacts, 2006b).

2.3 Literature Review

2.3.1 Consequences of Alcohol Consumption

Alcohol consumption has adverse consequences to those who consume, people around those who drink and as well the nations whose people drink more. These consequences can be classified as health, economic, and social consequences. Studies indicate different numbers as to how many medical condition are related to alcohol; it varies from more than 60 health

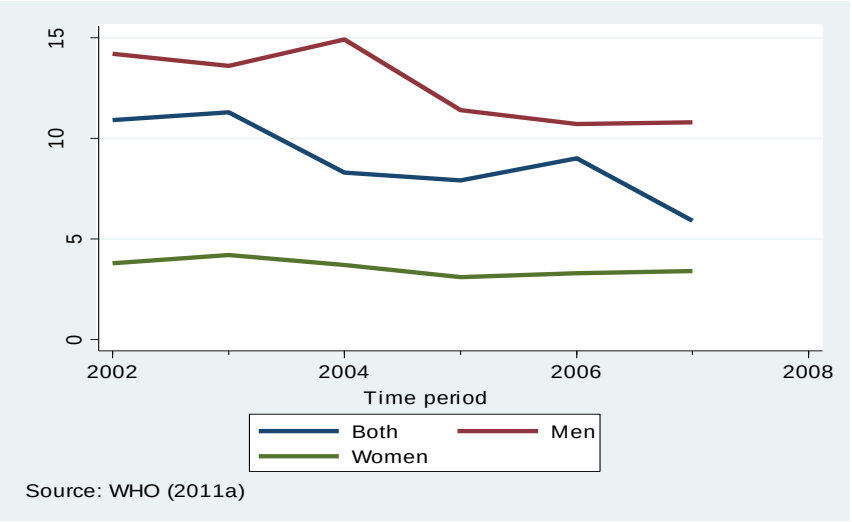
condition (Room et al., 2005) to more than 200 different diagnostic heath problems (WHO, 2011b) to be causally linked to alcohol consumption directly or indirectly; more than 30 of these medical problems are indicated to be either directly caused by alcohol use or alcohol is a necessary risk factor for the causations of these illnesses (WHO, 2011b). Alcohol use disorder; breast cancer; cerebrovascular disease; colon and rectum cancers; diabetes mellitus; drownings; falls; fires; ischaemic heart disease; liver cancer; liver cirrhosis; mouth and oropharynx cancer; oesophagus cancer; poisoning; prematurity and low birth rate; road traffic accidents; self-inflicted injury; other unintentional injuries; violence are among the most common known problems which are in one-way or another related to alcohol consumption.

The health consequence of alcohol is usually expressed both in terms of mortality and disability adjusted life years (DALYs). DALYs is a method of measuring the number of health years lost and ranges from 0 (perfect health) to 1 (death); it is a method of weighting the value of a lifetime with a certain disease (Arnesen and Nord, 1999). DALYs, first developed by the World Bank, is widely applied in health literature and policies as an important health care indicator (Lyttkens, 2003). The disability and morbidity burden of alcohol is more extensive than that of mortality (Rehm et al., 2003a). In this section the alcohol-attributable mortality and DALYs in Norway and the globe are briefly explained.

2.3.1.1 Alcohol-attributable Burden of Disease in Norway

There is little literature available about the burden of alcohol related diseases in Norway. However, according to the WHO statistics database, as the consumption level of alcohol in Norway is low so is its burden of diseases. Yet contrary to the increasing but stable level of alcohol consumption in Norway as shown in figure 2.2, the alcohol-related mortality for both men and women has been decreasing with little fluctuation for men. The alcohol-related disease mortality in Norway from 2002 to 2007 is shown in Figure 2-5 below. Alcohol-attributable disease mortality for 19 countries including Norway can be seen in appendix A.VII- Table 8-9. While the mortality attributable to alcohol was higher for male, it was low for both genders during this period. Less than 15 men per 100,000 died for alcohol-attributable diseases, whereas the figures are much lower for women, which are less than 5 deaths per 100,000.

Figure 2-5: Alcohol-related disease mortality in Norway, 2002-2007[1]



Source: WHO (2011a)

A little more detailed summary of the major causes of the alcohol-attributable burden of disease in Norway in 2004 both in terms of DALYs and Mortality is presented in appendix A.VII-Table 8-10. As the table 8.10 indicates the proportion of the burden differs between the 19 specific diagnoses as well as between men and women. Alcohol use disorder, Ischaemic heart disease and Cerebrovascular account for the highest burden with 969, 482 and 283 DALYs per 100,000 respectively for both genders. But the burden is higher for men than women in all these three cases with 1497, 725 and 316 DALYs per 100,000 respectively for men as compared 425, 254 and 253 DALYs per 100,000 respectively for women. With exception of breast cancer, and Prematurity and low birth rate, the alcohol-attributable DALYs are higher for men than women for the all diagnoses listed in table 8.10. Similarly, the Ischaemic heart disease and Cerebrovascular account the highest alcohol-attributable deaths with 72.7 and 37.3 deaths per 100,000 for both men and women respectively, the mortality attributable to alcohol is also higher for men than women with exception of the breast cancer only.

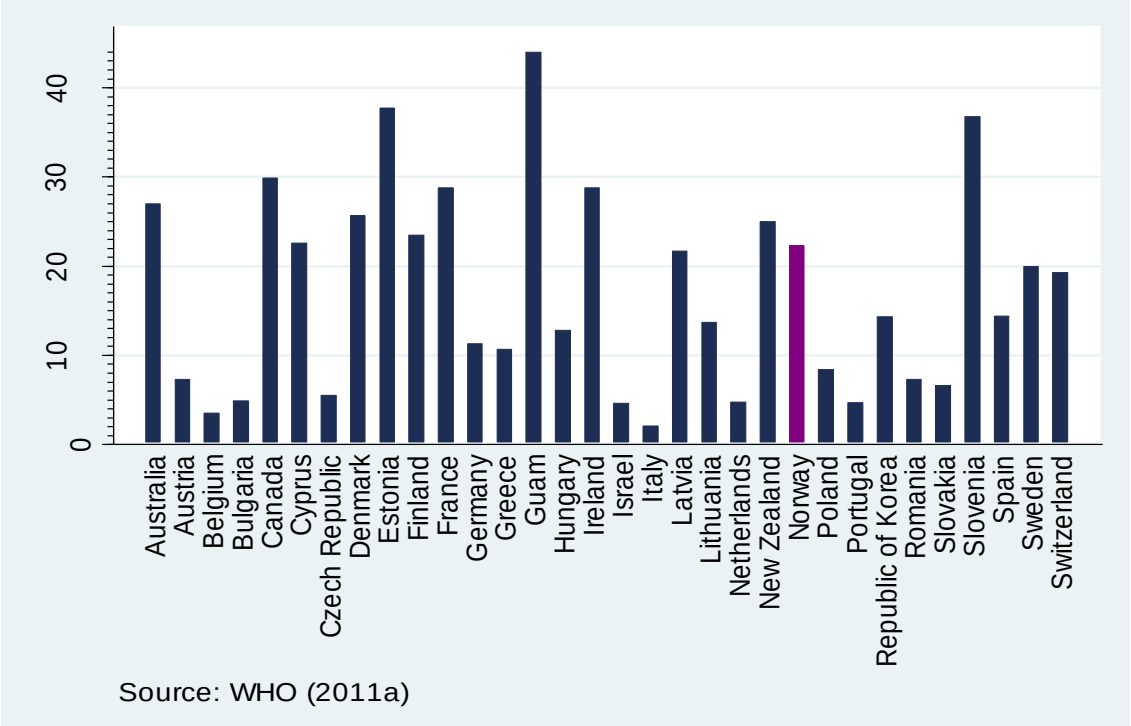
2.3.1.2 Alcohol as a Global Health Problem

There are widespread health, economic, and social problems associated to alcohol consumption throughout the world. Rutherford andMcNeill (2009) termed these problems as a worldwide epidemic harm resulted from high global consumption of this commodity. According to Greenfacts (2006a) the average volume of alcohol consumption is about five

[1] WHO estimates using Single, E., D. Collins, B. Easton, H. Harwood, H. Lapsley, P. Kopp and E. Wilson (2003). International Guidelines for Estimating the Costs of Substance Abuse, World Health Organization.

liters per person per year. It differs from region to region with highest alcohol consumption in Europe, as shown in figure 2-4. The alcohol-attributable deaths and disability is also highest in Europe, however, there is no region which is not affected by the alcohol harms (Rehm et al., 2009). According to WHO (2011b) around 2.5 million lives lost their live due to unsafe use of alcohol. Rehm et al. (2009) indicates that 3.8% of the total mortality and about 4.6% of the DALYS are associated with alcohol use. According to Rehm et al. (2009) the mortality and morbidity related to alcohol is higher for males than for females in all regions. The reason could be because, as Wilsnack et al. (2009) indicates, the average alcohol consumption of males is higher than that of females. In 2011 among the major risk factors causing death and DALYs globally was alcohol, which accounted 8th in mortality and 3rd in terms of morbidity (WHO, 2011b). Alcohol consumption victimizes not only by alcohol consumers but also non-alcohol users as it endangers the lives of those around when misused (Friedman and Klatsky, 1993). Premature and low birth weight for newly born children, accidents, violence, intentional and unintentional harms to other people are the common risks for other people (WHO, 2012). This clearly depicts how hazardous medical conditions associated with alcohol consumption, are in the global arena.

Figure 2-6: Mortality, road traffic fatalities involving alcohol (% of all road traffic fatalities) in 2005 in some selected countries



Source: WHO (2011a)

While the toxicity of alcohol consumption varies with the amount consumed (WHO, 1994), yet there is strong counter argument whether moderate drinking is safe and good for the health (Ashley et al., 1994; Melberg, 2006). Irrespective of moderate or heavy drinking habits, the harmfulness of this commodity is becoming more and more apparent. Control measures are demanded to reduce the risks of alcohol to the millions of lives throughout the world every year (Rutherford and McNeill, 2009). Accident involving alcohol consumption, which is one the main diagnoses entirely attributable to alcohol, results in high mortalities and morbidities throughout the globe. The road traffic fatalities involving alcohol drinking for 32 countries in 2005 is presented in figure 2.6 above. The figure is constructed from the estimated road traffic fatalities in appendix-A.VII, Table 8-8. Half of all these countries experienced more than 20% of all road traffic fatalities due to alcohol drinking in 2005. Norway is among these countries. According to Gjerde et al. (1993) 28% of injured drivers by car accidents in 1989 and 1990 were related to alcohol use; recent studies indicate high traffic incidents associated to alcohol (Gjerde et al., 2011). The figure 2.6 shows great variation between these countries; such kind of variation could be a result of alcohol drinking habits or other country specific factors.

Figure 2-7: Regional variations in proportion of alcohol-attributable deaths and DALYs in Europe, 2004

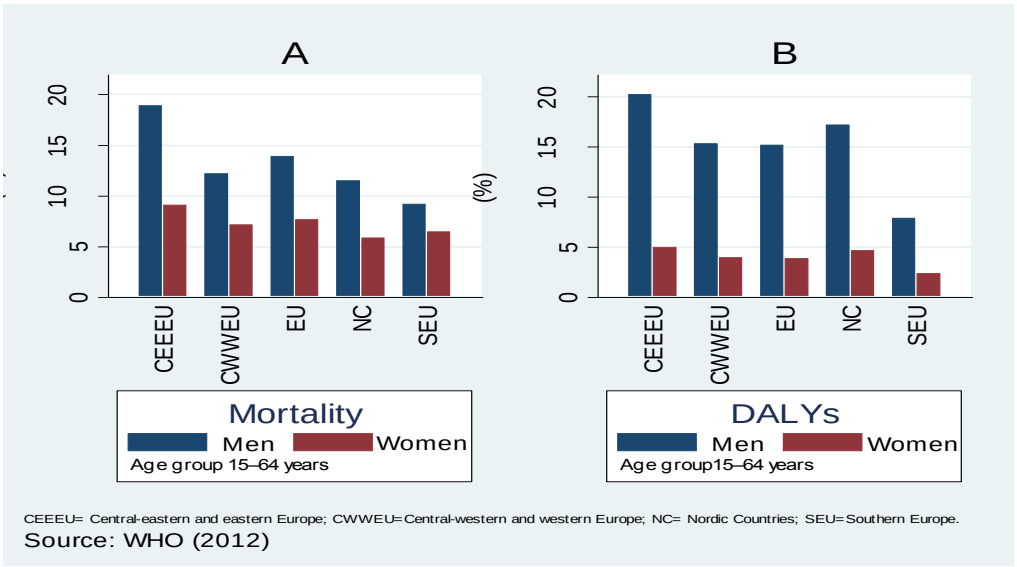


Figure 2.7 provides a picture of the proportion of alcohol-attributable deaths and DALYs in five European regions; shows high alcohol-attributable DALYs in the Nordic countries (NC), however, according to WHO (2012) this could be because of the longer life expectancy with disability in this region when compared the other four regions. As the figure 2.7 shows the burden of disease is higher in Central-eastern and Eastern Europe (CEEEU) both in terms of

mortality and DALYs. According to Popova et al. (2007) the high alcohol-attributable burden of disease in CEEEU is associated with the high consumption of alcohol in this region when compared to other parts of Europe.

2.3.2 The Economic Burden of Alcohol Consumption

Health care spending as a share of the GDP in all OECD countries was increasing for the past half century. And although the Norwegian health care spending as a share of its GDP is not that much higher than the average OECD countries' spending; the adjusted health care per capita spending shows otherwise which is, extremely high. In the later case, Norway is the second highest next to United States (OECD, 2009; OECD, 2011a).

The increasing health care expenditure are due to, among other things, the good living standard of the individuals, the high life expectancy which increased the aging population, and the innovation and using new advanced technology, treatments and procedures in medical sector (Jones, 2004). However, there no debate that the rises of chronic illness have a huge contribution to the increasing health care costs. Finding different health care cost drivers are essential for future cost control and prevention.

The cost of alcohol related diagnosis is no exception since as mentioned above many of these chronic diseases are attributed to consequences of alcohol use. Whether the health and social consequences are causally attributable to alcohol consumption or whether the general condition of treatment methods of the diagnoses are affected by indirectly by alcohol consumption; whole or fractions of the economic losses due to these health consequences are to be regarded as alcohol-caused losses. These losses are what constitute the economic burden of alcohol, which, according to Thavorncharoensap et al. (2009), is immense globally.

Table 2-1: The Overall comparison societal cost burden of alcohol

	Year of cost	Total tangible costs % of GDP	Total cost per capita (inc. intangibles) PP € 2003†		Year of cost	Total tangible costs % of GDP	Total cost per capita (inc. intangibles) PP € 2003†
Australia [28,89]	1998/9	0.9–1.0	286–315	Netherlands* [90]	1996	0.3	78
Belgium* [91]	1999	2.4	586	New Zealand [29]	1990	4.7	4289
Canada [2]	1992	0.9–1.3	195–265	New Zealand [92]	1991	1.4–2.4	234–386
Canada [21]	2002	0.7–1.7	180–451	New Zealand‡ [59]	1996	–	–
Denmark	1996	0.9	218	Norway [93]	2001	1.2–2.1	447–729
England and Wales [42]	2001	1.5–1.7	456–497	Portugal [43]	1995	0.5	73
Finland [57]	1990	1.3–1.8	482–823	Scotland [94]	2001/2	0.7	296–360
France [95,96]	1997	1.2–1.4	256–300	Slovak R. [97]	1994	3.1	292
France [98]	1996	–	–	Slovenia [99]	2002	0.3	50
Germany [61]	1995	1.1	253	Spain [100]	1998	0.7	129
Ireland [101]	2003	1.6	447	Sweden [102]	1998	5.5	1,194
Italy [103]	1994	0.7–0.8	134–153	Switzerland [38]	1998	0.5–0.7	435–482
Japan [44]	1993	1.9	381	United States [46,104]	1992	2.3	666–731
Latvia [105]	1999	1.8	113	United States [60]	1985	1.7	447
Netherlands [45]	2000	0.7	171	United States‡ [58]	1995	–	–

Source: Adapted From Baumberg (2006)

In 2002 the cost of alcohol consumption was estimated between $210 – 665 billion globally (Baumberg, 2006). According to Rehm et al. (2009) both high and middle-income countries spend 1% their gross national product (GNP) due to the detrimental effects of alcohol consumption. In Norway NOK 18 – 19 billion were estimated to the economic cost of alcohol burden (Gjelsvik, 2004); in 2003the total tangible cost of alcohol accounts for about 1.2% - 2.1% of GDP as shown in table 2.1 above (Baumberg, 2006). WHO database for the economic burden of alcohol shows substantial social costs of alcohol; in 2000 more than $200 billion losses were attributed to alcohol in United State of America (USA). Half of these costs were indirect costs. Germany (in 2007) and United Kingdom (in 2003) lost more than $30 billion due to alcohol use (WHO, 2011a). The table 2.1 above gives a picture of economic and social cost of alcohol.

3. Theories

3.1 Theories of Alcohol Use

In almost all social perspective towards the negative effect of alcohol, the dependency problem is apparent, however, according to some studies, low and moderate consumption of alcohol is more beneficial to health rather than harming (Ashley et al., 1994; Ashley et al., 1997; Doll, 1998). These conceived beliefs could be the reason why most of the theories of alcohol consumption address the substance misuse, which confines to theories of alcohol to the problem of dependency. In other words they focus on problems related to alcohol misuse rather than alcohol use. Moreover, the theories of alcoholism are divided over the issue of alcohol abuse whether it is habit or a disease (Korhonen, 2004). One of the mainly applied theories to alcohol use is the behavioral theory, it is widely applied to college students' and adolescences' alcohols misuse. It is a very wide concept of theory applied as individual, social, economic, and sometime parental behavior. It is a broad concept and cannot be explained in depth in this study. Those interested to know more about behavioral theory of economics can refer the editorial article of Bickel et al. (1995). In this section it is briefly pointed out the behavioral economics. The intention of the behavioral theory of addiction or misuse of alcohol should not be misunderstood here; it is not to generalize to the overall drinking habits; but to enlighten how some of the most well known alcohol problems arise.

Economists are divided over how to apply the behavioral theory to alcohol dependency. There are those who argue that addiction to alcohol for example, is an economically rational behavior that individuals make just as they do in other normal goods (Tomer, 2001). They base their arguments to Gary Becker's rational theory of addiction, who argued in the late 1980s that addiction is consistent to the rational theory of maximizing utility (Becker and Murphy, 1988). Becker andMurphy (1988) explained how addiction is simply a means of trying to reach a stable point, but the current consumptions' negative effect to the future consumptions' utility increases the consumption of the addictive good in the future; which is as they argued normal behavior. They also tried to justify their theories by indicating how addiction behavior applies to wide varied normal goods. Bask andMelkersson (2004) argue that alcohol addiction in particular is consistent to rational behavioral theories of economics. However, Tomer (2001) explained by using psychological and physiological point of view that addiction is not rational behavior. For an individual to make a rational choice, he/she has to have control over his/her choices both pre and post consumption of the addictive good. There are external factors like economical, social, psychological, and physiological, which

cause the individual to over consume the addictive good at the first place (Tomer, 2001; Korhonen, 2004). This leads to addiction which later on his/her lifetime takes control of the individual decision making process regarding to the amount alcohol consumed (Tomer, 2001).

The point here is not whether an addiction is rational or not, but the pattern that leads individuals to consumes more of a toxic substance like alcohol. While both arguments explain how addiction develops, later argument of Tomer (2001) is more applicable in real life, because it takes into consideration the external factors which influences pre and post addiction. By acknowledging the harmfulness of the addictive commodity, Tomer (2001) incorporates the habit point of view of alcoholism to that of the disease point of view.

3.2 Alcohol-attributable Fractions (AAF)

It was explained in the previous sections how wide and complex is the burden attributable to alcohol consumption throughout the globe in terms of economic, social and health consequences. How to estimate these consequences are the main challenges faced by many of the studies conducted about this area, because of the multiple risk factors involving same health problem. The majority of the health consequences related to alcohol are partially attributable to alcohol consumption, so it would be misleading if the whole consequences of these partially related disease recorded as alcohol-related burden. In Epidemiology it is very important to quantify the fraction of the burden of a disease that is related to a particular risk factor (Laaksonen et al., 2010). The mainly used method of quantification is the population attributable fraction (PAF) which assigns the proportion of the risk to the multiple risk factors found to have causal link to the occurrence of a particular health problem in a given population (Laaksonen et al., 2010). The PAF is commonly defined as a means to differentiate the occurrence of the disease between those exposed to the risk factor and those not exposed in same population (Jones et al., 2009). PAF is superior to other epidemiological measures like relative risk and odds ratio, because it considers both the prevalence of the risk factor and the strength of the causation between the risk factor and the health outcome (Laaksonen et al., 2010). Since its introduction in 1953 by Levin in his study of the occurrence of lung cancer in man (Rockhill et al., 1998) PAF has been used and applied to very wide and varied health conditions (Laaksonen et al., 2010). Alcohol-attributable fraction (AAF) is one of the PAFs, which is applied to alcohol as risk factor to many chronic and acute health conditions. It specifically measures the proportion of health consequences that is attributable to alcohol consumption. It is used to estimate the partial risk function of the share of a disease or other

health consequence that is positively related to alcohol drinking (Jones et al., 2009). In other words, it estimates that proportion of diseases mortality and morbidity that would not have existed had it not been alcohol consumption (Taylor et al., 2011). AAF makes the quantification easier and closer to accuracy and thereby helps to introduce appropriate policy intervention.

The relative risk of specific disease could differ between male and female; it could also differs among the age-groups of same gender (Eshima et al., 2012), because of this reasons, different AAF is applied to men and women, and to different age-groups. This method of quantifying alcohol risk fraction is conducted in many countries worldwide. When the term alcohol-attributable fraction is searched in PubMed database 186 results were found (Searched date: 04 August, 2012). Among them are (Rehm et al., 2006; Taylor et al., 2011) conducted in Canada, (Cherpitel and Ye, 2008) in US.

3.3 Economic and Societal Cost Studies of Alcohol Consumption

As mentioned in the introduction, numerous evaluations for the consequences linked to alcohol are conducted regularly. The convoluted and indistinguishable multidimensional relationship between the alcohol consumption and related health problems (Rehm et al., 2010) make vital for such continuous evaluation of alcohol consequences. As the health consequence of alcohol affects not only to the drinkers but also the whole individuals surrounding to them like family members and friends, so is its economic consequence (Navarro et al., 2011). The social and economic costs of alcohol are wide and affect the whole economy. It is not a surprise that one of the focal and well-known among alcohol related studies is the economic evaluation, which explores the economic burden of alcohol consumption to the society.

These kinds of economic evaluations examine different perspectives, broadly the linkage between the cost burden of alcohol and its consequences, and the costs of the alternative treatment options for the alcohol related diseases and treatment outcomes. Drummond et al. (2005) defined the economic evaluation *'as the comparative analysis of alternative courses of action in terms of both their costs and consequences… to identify, measure, value and*

compare the costs and consequences... '. It is a widely applied method in health economics. French (2000) listed more than 30 studies of economic evaluation of alcohol treatment services since 1983. Many more studies were conducted since French published his study. Baumberg (2006) included 30 alcohol cost studies in his study of global economic burden of alcohol since 1990. Table 2.1 adapted from Baumberg (2006)can be seen the societal cost of alcohol from different countries. Same applies to other economic evaluation perspectives related to alcohol.

There are increased various uses of the findings of these studies like decision making on prevention, reduction of alcohol consumption or cost minimization of the treatment options of alcohol-related illnesses (Thavorncharoensap et al., 2009). There are three main methods of economic evaluation for comparing costs and consequences; namely cost-benefit analysis, cost-effectiveness analysis (CEA) and cost utility analysis (Drummond et al., 2005). This kind of classification is not important for this study, however, what most, if not all economic evaluations have in common is the inclusion of the indirect costs and opportunity cost.

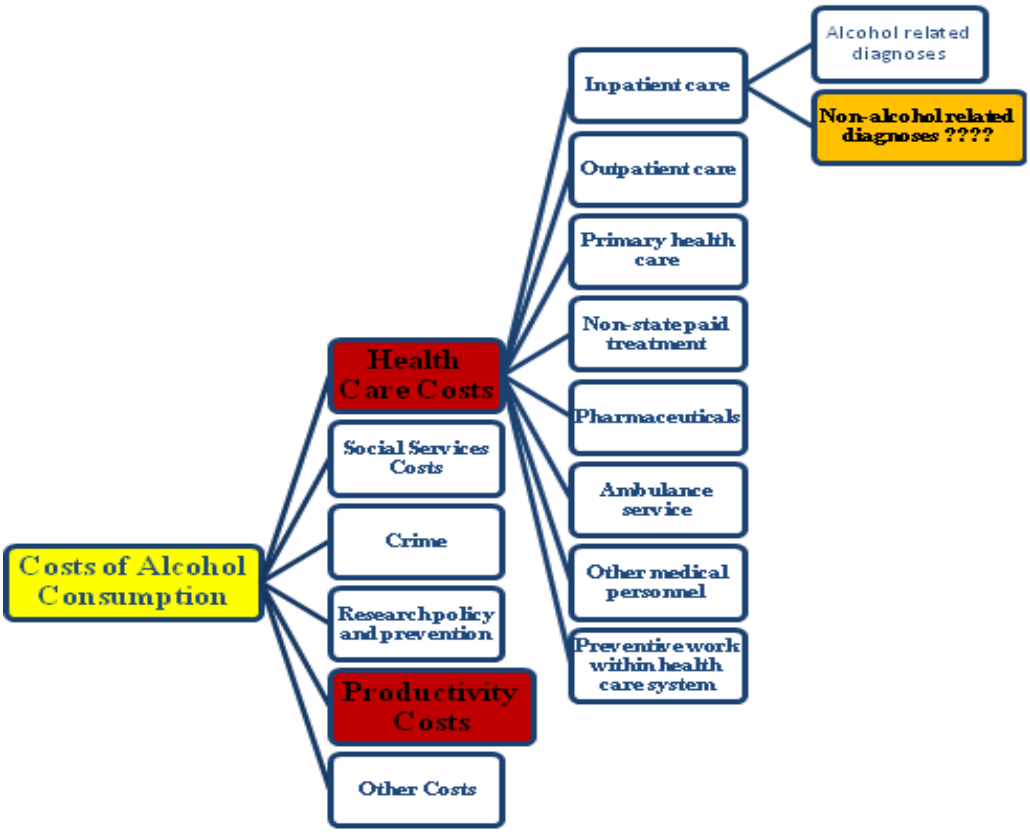
3.3.1 Cost Inclusion of the Economic Burden of Alcohol

There are many cost items included for the economic burden of alcohol as its consequences. Some of the most commonly considered cost items of alcohol are presented in the figure 3.1 below. The largest cost components of alcohol are health care costs, social services, crime, and research, policy and prevention (Jarl et al., 2008). Detailed explanation of these components are not important here, however, the important point is to recognize that health care costs includes not only the attributable fraction of alcohol-related diagnoses but also fractions of costs of some non-alcohol-related diagnoses which is believed that alcohol has impact on the effectiveness of the treatment methods and recovering process (Johansson et al., 2006).

Does alcohol have some effects on the treatment process on causally non-alcohol-related diagnoses? Are all diagnoses with unknown alcohol-association that somehow alcohol affects their treatment being considered in economic evaluation of alcohol costs? If not so, which are the most probably ones, how big and significant are these costs? These questions and other related ones are the main focus of this study. The complex association between alcohol consumption and its harmful consequences mentioned before made ambiguous as to what cost items be considered and there are wide differences among the respective literatures (IAS, 2007).

The burden of alcohol affects the whole economy and almost every sector. The productivity loss due to alcohol use is a widespread loss which directly or indirectly involved many sectors. But the complexity involving such losses makes always impossible to capture the true productivity loss. However, as Thavorncharoensap et al. (2009) indicated there is high percentage of alcohol-related costs which indirect costs; and the productivity losses of the other sectors are recorded as indirect costs.

Figure 3-1 Cost Items of Alcohol Consumption



Alcohol prevention policy become a global campaign, the economic evaluation studies described above are used the main engine for developing and implementation of appropriate policy towards reduction of alcohol consumption. Reduction of alcohol consumption was found to have substantial economic benefit; which results from lower mortality and morbidity, reduction of health care expenditure and productivity loss as the incidence of diseases associated to alcohol and absence from work declines (Magnus et al., 2012).

3.4 Co-morbidity and Multi-morbidity

Co-morbidity is defined into different ways in different literatures; it is sometimes used interchangeably as multi-morbidity, patient complexity and other terms (Safford et al., 2007; Valderas et al., 2009). It is commonly referred as either the coexistence of several diagnoses together or additional diagnoses to an index diagnosis (van den Akker et al., 1996; Fortin et al., 2005). Either way the implication is that patient has several diseases (diagnoses), which are occurring at a same time span. This does not mean that diseases occurring starts and ends at same specific time, but it means that during a period a patient had a disease; other diseases also occur to the same patients before he/she recovered from the previous disease.

In epidemiology, co-morbidity was always a problem, the clinical attention improved from the last two decades (van den Akker et al., 1996) as compared to four or five decades ago (Feinstein, 1970). Co-morbidity of the chronic diseases is more usual and it is higher for the elderly population (van den Akker et al., 1996; Gijsen et al., 2001). While co-morbidity does not usually mean that these diseases cause one another (Hall et al., 2001), yet it is a burden to the patient as it increases the vulnerability of the patient and the likelihood of dying due to an index diagnosis (Gijsen et al., 2001). It lowers the health quality of life; and moreover, it affects the recovering process of the patients from an index disease by complicating the diagnostic and treatment procedures; which in turn increases the cost of treating a patient from an index disease (Fortin et al., 2007a; Fortin et al., 2007b; Valderas et al., 2009).

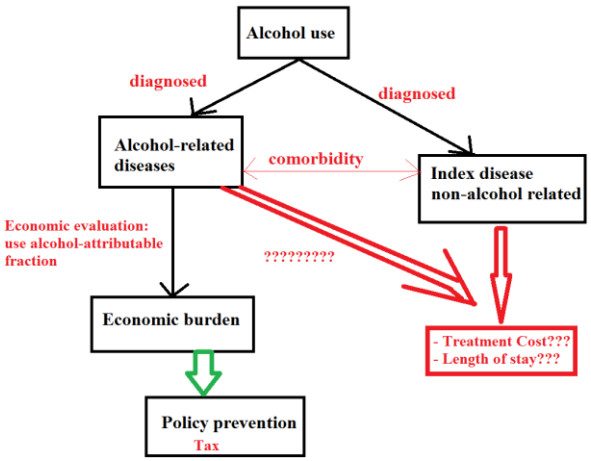
In this paper, the concept of co-morbidity is used to imply the coexistence of alcohol-related diseases with other non-alcohol-related disease. The index diseases are the non-alcohol-related diseases and the effect of alcohol-related diseases on treatment costs for these index diagnoses is the main focus of this paper. While the co-morbidity is a universal problem to all diagnoses, whether diseases are alcohol-related or not, how to manage the economic loss due to the co-occurrence of diseases is an important question. Problems of estimating the clinical burden of co-morbidity (Fortin et al., 2005), could also be an obstacle to quantify the economic losses attributed to different diseases which coexist.

4. Study Design and Methodology

4.1 Conceptual Framework

There are many different types of alcohol. The term alcohol as meant here is the alcohol people consume as beverages like wine, beer and spirits. This definition is consistent with the definition used by the international handbook on alcohol and culture (Heath, 1995). The limited availability of data in this study, constrains a better way of classifying patients into alcoholic and non-alcoholic; or into heavy drinker and moderate drinker. However, since with high consumption of alcohol the risk of alcohol-attributable diseases increase (Bentzen and Smith, 2011), it was assumed that all patients above 18 years with alcohol-related diagnoses were alcoholic. Those patients without alcohol-related diagnoses were assumed to be non-alcoholic. Here non-alcoholic was not meant abstainers, since there could be some patients who in reality drink, but did not show symptoms of the diseases related to alcohol yet. Neither was alcoholic meant heavy drinkers, as moderate drinkers could have alcohol-related diseases. So the terms alcoholic and non-alcoholic were used here just to distinguish those with alcohol co-morbidities from those without these co-morbidities. The figure 4.1 below illustrates the general conceptual framework of this study.

Figure 4-1: Conceptual framework of the study



As mentioned in the background section, the relationship between diseases and alcohol consumption is very complex. The multi-causality of diseases also makes it more difficult to capture the true consequences attributable to alcohol. A method of estimation for the consequences (loss) of alcohol was developed for those diseases with known alcohol association. This method is called alcohol-attributable fraction (AAF), as explained in the

previous section. Economic evaluation of alcohol bases their estimation of economic loss of alcohol consumption by AAF. It is these economic evaluations and analyses which are later used for the development of preventive and reduction policies.

There are many other diagnoses, which the relationship with alcohol is unknown. The question is whether the treatment of patients who were diagnosed with alcohol-related health problems is more costly than other patient. If this is the case, then it means non-alcohol-related diagnoses which are more costly because of alcohol consumption (alcohol comorbidities) have to be included in economic evaluations by developing and estimating the fraction which is attributable to alcohol. By including such costs, if any, would lead to a reduction in the underestimation of economic burden of alcohol, and hence more effective control and preventive policies of alcohol consumption.

While environmental and geographical factors complicate the development of cost estimation for such diagnoses, continuous researches and developments in this area are always feasible and are essential for achieving it. The empirical analysis of cost and cost comparison between alcoholic (those with alcohol co-morbidities) and non-alcoholic (those without alcohol co-morbidity) of this study is expected to contribute.

4.2 Data Collection

The study was based on a dataset of Norwegian Patient Registry (NPR) in 2008. The Department of Health Management and Health Economics at University of Oslo originally received the data for other studies. The data initially contained more than 1 million observations of which more than 400,000 observations were not eligible and excluded due to age limit of 18 – 79 years. The registry had more than 7000 specific diagnostic conditions based on International Statistical Classification of Diseases and Related Health Problems 10th Revision (ICD-10). Length of hospital stay (LOS), demographic features, and costs incurred for each specific treatment estimated based on DRGs system estimation were included in the data. The NPR collects patient records from both public and private hospitals (Bakken et al., 2012). However, since the Norwegian health care system is dominated by the publicly owned health institutions (EUOHCs, 2000), the records of the dataset were mostly from public.

The data had patients with multiple observations, so the structure of the data was longitudinal observation. This means same patient was admitted repeatedly in hospital care during the year

2008. In order to fit the data for the applicability of the appropriate statistical models explained in the model section (4.7) of this chapter; the data was reshaped by collapsing it in a long format for identical specific diagnosis at different hospital admissions during the year of 2008.

4.3 Grouping and Selection Criteria

In order to examine whether alcohol indirectly effects on the treatment process of non-alcohol-related diagnoses (diagnoses not yet discovered to be associated with alcohol consumption, or diagnoses which are not usually included in alcohol cost estimation), the data observations were classified into two groups. The alcoholic group that was the group of interest and a control group which contained patients who were not diagnosed with alcohol-related diseases. It was noted with the difficulties and complexity involving on how to group patients without any record of drinking habits available in the dataset. However, a selection criterion was developed based on diagnostic records of patients. Patients diagnosed with diseases that are either fully (Appendix-A.I-Table 8.3) or partially (Appendix-A.I -Table 8.4) attributable to alcohol were included in the alcoholic group. The rest of patients were considered to be non-alcoholic. It is important to remember the meaning of alcoholic and non-alcoholic as it was described in the conceptual framework (4.1). The ICD-10 classification codes were used as a tool for selection process.

4.3.1 Diagnoses Selection

The diagnoses of interest were not the alcohol-related diagnoses but instead the unrelated diagnoses, the diagnoses that were common to both alcoholic and non-alcoholic groups. Based on these criteria more than 350,000 observations of non-alcoholic group and around 90,000 alcoholic group have been diagnosed to more than 6000 specific diagnostic health conditions which were not related to alcohol and/or is not included to economic evaluations of alcohol.

All the diagnoses, which studies indicated association with alcohol consumption like malignant neoplasms (Cargiulo, 2007); intestinal infectious diseases (Cook, 1998); nutritional anaemias (Ioannou et al., 2004); diseases of the eye and adnexa (Kaimbo et al., 2001); inflammatory polyarthropathies (Jaakkola and Gissler, 2005); and Renal failures (Perneger et al., 1999) were excluded since the diagnoses of interest were those diagnoses that are not

related to alcohol. Other follow up diagnostic procedures were also excluded as there was little information about the diagnoses followed up. Still there were many specific diagnoses included in the data registry. However, most the diagnoses had very small observations, and it was not possible to compare the two groups. Further selection process was conducted based on sample sizes of all these specific diagnoses.

In order to exclude those diagnoses with fewer observations in either of the two groups, a criterion of at least 100 observations per group was set before collapsing dataset. Finally a total number of 21,105 observations (table 4.1): 18,203 control groups and 2,902 alcoholic groups for 8 specific diagnoses were selected and applied in the analysis. As the table 4.1 below shows, the frequency distribution of gender with respective group-category and diagnoses was not that much different between women and men. The 8 diagnoses listed in table 4.1 were selected for two main reasons. First these diagnoses were not included in the literature of economic evaluation of alcohol (because there are no known association between alcohol and these diagnoses), and second these diagnoses had the maximum comparable observations when compared to other diagnoses. The 8 diagnoses are: -

Erysipelas (A46) is a skin infection caused by streptococci. While it could be cured with simple treatment methods like antibiotics, erysipelas is a serious infection which can lead to potential harmful situation if not controlled properly (Eriksson et al., 1996; Dupuy et al., 1999). Although it affects the legs, yet hospital admission to the patients affected is common, which creates debates about the cost issue (Eriksson et al., 1996; Dupuy et al., 1999). While some studies consider alcohol misuse as risk factor for the Erysipelas (Dupuy et al., 1999), its costs of treatment are hardly considered when estimating the economic and societal cost of alcohol.

Volume depletion (E86) also called as extracellular fluid depletion is a condition which body cells loss both water and sodium salt fluids (Spital, 2007; Bhave and Neilson, 2011). Volume depletion is different from dehydration pathophysiologically as well as the treatment procedure required (Spital, 2007; Bhave and Neilson, 2011), but it is similar to dehydration. It causes low blood volume circulation (Bhave and Neilson, 2011). There are no available studies which could link alcohol as a risk factor for volume depletion.

Unspecified asthma (J459): Asthma is a potential risk condition for both children and adults which results mostly in morbidity and sometimes death. Enormous medical resources are used to deal the problem of asthma and patients are hospitalized for the specific treatment of

asthma (Sears, 1997; Lugogo and Kraft, 2006). The risk factors and causes of asthma are very complex, and there are many things that are not known yet, however genetic and environmental factors are usually associated with the cause of asthma (Lugogo and Kraft, 2006). In ICD-10 codes there is a diagnostic asthma condition (J459), which is unspecified; as the name indicates it is not known what kind of asthma it is or what causes it.

Acute tubulo-interstitial nephritis (ATIN- N10) is an inflammatory disease which patient gets high blood urea nitrogen (Ulinski et al., 2012). It is associated to early acute renal failure, several drugs including Non-steroidal anti-inflammatory drugs (NSAIDs), infections, and toxins (Vanhaesebrouck et al., 1985; Rocha and Fernández-Alonso, 2001; Ulinski et al., 2012). It could impair the proper function of the kidneys because 95% of the kidney contains interstitium and tubules (Ulinski et al., 2012); therefore patients are usually hospitalized to avoid the risk associated with this diagnoses.

Unspecified Chest pain (R074) is a non-cardiac chest pain which is not known the underlying cause (Eslick, 2008). A chest pain, usually treated at the primary health care, occurs to a large number of people of all ages (Eslick et al., 2003; Ruigomez et al., 2006; Eslick, 2008). There are multiple risk factors for chest pain, among the commonly associated ones are gastrointestinal, cardiac, musculoskeletal, psychological, family history, neuroticism, dysphagia, malignant and pulmonary diseases (Ruigomez et al., 2006; Eslick, 2008). The unspecified chest pain, though not known what causes, can result in detrimental effect on the health and endanger the life of the individuals (Ruigomez et al., 2006). Patients are commonly admitted in hospital emergency but also hospitalized for this diagnosis.

Pain localized to upper abdomen (R101) Abdominal pain is horrid abdominal tenderness which can be chronic or acute health condition. It involves tissue injury influenced by both path-physiological and psychosocial factors (Glasgow and Mulvihill, 2002). While it is not always the case, abdominal pain could cause death (Flasar and Goldberg, 2006); and it is a very complex diagnosis which is sometimes treated as inpatient. One of the specific diagnoses related to abdominal pain is the one localized to the upper abdomen.

Unspecified fever (R509) is a high temperature of patients with unknown cause (Bodenreider, 2001). A patient is said to have fever if his/her body temperature is greater than 38°C. It is usually a reaction of body for some underlying infections (Kluger et al., 1998). While fever is not life threatening condition to the adults, however, extreme fevers (as 45°C) not only

destroy tissues and body cells, but can also kill patients (Dubois, 1949). Besides the unknown factors causing the fever can impair the health quality of the individual if not given proper action. So patients are hospitalized for unspecified fever.

Other and unspecified convulsions (R568) **–** Convulsion is a complex chronic health conditions which needs to be monitored with its simple seizure, epilepsy or other convulsive disorder. There are cases which is ambiguous as to what kind of convulsion it is, these kinds of convulsions, which are not epilepsy, are called unspecified convulsion in ICD-10 (Jetté et al., 2010).

4.4 Problems and Data Limitations

The registry data lacked individual specific characteristics like history, lifestyle (smoking, exercise…etc) and more importantly the drinking and other diet habits of the individuals. These missing factors would help not only to distinguish the alcohol consumers from non-alcohol consumers, but also could have been used as control variables to capture the pure effect of alcohol consumption to the treatment cost and LOS. These factors were assumed to be random and equal to all individuals, and therefore it accounted the biggest limitation of this study. It limited the generalizability of the findings of this study. Moreover, as many retrospective observational data are subjected to errors of measurement, so was this study. A measurement error in this study could be misdiagnosis of the patients which is a common error in diagnostic procedures.

Moreover, the selection criteria for identifying the observations into alcoholic and non-alcoholic could lead selection bias, as there is no record of alcohol drinking in the dataset. For example, there is a possibility to have a disease partially attributable to alcohol although the individual was in fact abstainer. If this happens, it means such kind of individual was identified as an alcoholic. While it is important to take these limitations into consideration when interpreting the results, the findings of this study could still be used to reevaluate the cost estimation of alcohol burden.

4.5 Data and Variable Description

4.5.1 Data Description

The sample size and frequency distribution of the two groups is presented in table 4.1 below. As the table indicates the frequency distributions of the two groups were different. The total sample size of the alcohol group was only 2,902 observations, which is less than 15% of the total observation of the study (21,105 patients). Unbalanced sample size are common on retrospective observational studies.

Table 4-1: Sample Size and frequency distribution by gender

	Women		**Men**		**Both**		**Total**
Diag	Non-alcohol	Alcohol	Non-alcohol	Alcohol	Non-alcohol	Alcohol	
A46	850	96	1470	159	2320	255	2575
E86	235	110	164	87	399	197	596
J459	423	60	204	31	627	91	718
N10	1159	127	465	107	1624	234	1858
R074	5071	724	5914	955	10985	1679	12664
R101	618	94	408	88	1026	182	1208
R509	181	52	199	46	380	98	478
R568	352	62	490	104	842	166	1008
Total	8889	1325	9314	1577	18203	2902	21,105

A46 – Erysipelas; E86 – Volume depletion; J459 – Asthma, unspecified; N10 – Acute tubulo-interstitial nephritis; R074 – Chest pain, unspecified; R101 – Pain localized to upper abdomen; R509 – Fever, unspecified; R568 – Other and unspecified convulsions

The cell variations of the two groups became even wider as the observations of the data were categorized based on the 8 specific health conditions. As presented in last three columns of the table 4.1 above, the sample size difference between the two groups in most of these diagnostic categories was very wide. The problem of unequal cell size between the two groups usually creates heterogeneity of variance between the two groups. While this was a limitation of the data distribution, it was taken under consideration when developing an appropriate statistical model by assuming heterogeneous variance when suspected (refer to section 4.7). The health conditions listed in the table are disease specific diagnoses, which are very precise health conditions.

4.5.2 Variables Description

The main variables of interest were the treatment cost, the length of stay (duration of hospital treatment in days), alcohol (alcoholic and non-alcoholic), and other variables like age and

gender, which were used to control individual specific character. As mentioned in the previous sections the main objective of the study was to find out whether LOS and cost differed between the alcoholic group and the non-alcoholic group. Both variables were included in the descriptive statistics as well as in the main results analysis. In descriptive statistics mean and standard deviation were used for both variables. However, in results analysis two different models (section 4.7) were applied to LOS and cost, mainly because of the varied nature of the two variables.

Table 4-2: Type and nature of variables

variables	type	nature	categories	unit of measurement
Cost	Dependent	continues	-	Norwegian kroner
Length of stay (LOS)	Dependent	continues	-	days
alcohol factor	explanatory	category	2 groups	Non-alcoholic '0' Alcoholic '1'
Gender	control	category	2 groups	Female '2' Male '1'
Age	control	category	2 groups	18-49 '0' 50-79 '1'

The private costs and production loss were not included, which means the cost estimation was purely institutional cost, not societal cost. The unit of measurement for cost variable was Norwegian Kroner value of 2008. The variable LOS was a discrete count variable (LOS_i = 0 1 2 3… n), which was the total number of days patients hospitalized for specific diagnosis during 2008. The alcohol factor (variable) was a categorical dummy variable of two groups, that was the alcoholic group coded as "1" and the non alcoholic group as "0". This variable was the main explanatory variable intended to measure. The drinking habit of individuals was not available; therefore, individuals were categorized based on diagnoses related to alcohol (see section 4.3). Other variables like gender and age were also included in the explanatory variable to find any effects that these factors might had on the result. Both of these factors were also categorical variables. The gender was as usual two categorical groups where "1" is coded for male and "2" for female, a dummy variable was not created for this variable, because models were applied separately for male and female observations. The objective was to clearly capture the effect of alcohol factor on treatment, so in this case same gender observations but different groups (Alcohol factor) were compared. In appendix A.I, the gender effect is presented and male was taken as a reference group. The third explanatory variable "the age" was categorized in two different ways; one for descriptive statistics and the

other for regression models. In the descriptive statistics, age was grouped into seven categories. However, age was grouped into two categories (i.e. 18 – 49 coded as "0"; and 50 – 79 coded as "1") in regression analysis due to reasons related to cell size.

4.6 Descriptive Statistics

The simple descriptive statistics cannot be used to conclude significant variations between the two groups. However, the descriptive statistics help to explore and easily discover whether there are variations between and among groups. Table 4.3, Table 4.4, Table 5.1, Table5.2, and Figure 4.2 – Figure 4.5 provide simple descriptive statistics of hospital treatment cost and length of stay (LOS). The mean and standard deviations of both LOS and hospital treatment cost by alcohol group (diagnoses with alcohol related diseases or not) and gender are displayed in table 4.3 below. The mean difference between and among groups is presented in table 4.4. Figure 4.2, figure 4.3, figure 4.4 and figure 4.5, supplement the information given in Table 4.3 and Table 4.4. In these figures the age factor is included, and therefore more information is provided in these figures by comparing the cost and LOS of the alcoholic and to that of the non-alcoholic by gender and age.

As the table 4.3 indicates the alcoholic group (patients with alcohol related diseases) had higher hospital treatment costs and longer LOS than control group (patients without alcohol-related diagnoses) for all 8 specific diseases except the unspecified fever (R509). The non-alcoholic had 0.15 longer LOS than the alcoholic group for the unspecified fever as shown in table 4.3 and table 4.4. The mean differences can be easily observed in table 4.4 below.

4.6.1 Descriptive Statistics for Hospital Treatment Cost

The cost variation between alcoholic group and non-alcoholic group is wider in the unspecified Asthma (J459) diagnosis. The alcoholic group had NOK 21745.4 more cost than the non-alcoholic group for the treatment of unspecified asthma. The unspecified chest pain (R074) diagnosis had the smallest cost variation (NOK 1498.4) between the two groups. However, due to sample size differences between the alcoholic and non-alcoholic groups, the cost dispersion from the mean was higher in the alcoholic group than in the non-alcoholic for all diagnoses except the Erysipelas (A46). The difference of the variability of hospital treatment cost for the two groups was worse for the unspecified Asthma (J459) diagnosis. In this diagnosis, the dispersion of the cost for the alcoholic group (SD = 103,724.6) was six times higher than that of the non-alcoholic group (SD = 15,953.47).

Table 4-3: The average cost (in NOK) and Length of stay (in days) by gender between alcohol and non-alcohol consumer

Diag		(1) Men non-alcohol	(2) alcohol	(3) Women non-alcohol	(4) alcohol	(5) Both non-alcohol	(6) alcohol
A46	Cost	33400.7 (26490.3)	41787.9 (18442.8)	34407.0 (18018.3)	42314.6 (27379.1)	33769.41 (23740.64)	41986.18 (22181.43)
	LOS	4.891 (4.941)	6.277 (4.755)	5.241 (5.669)	6.750 (6.125)	5.019397 (5.220706)	6.454902 (5.305335)
E86	Cost	24525.4 (26541.2)	35302.3 (31394.3)	22716.7 (15904.4)	27783.2 (20490.7)	23460.14 (20928.73)	31103.83 (26076.24)
	LOS	3.232 (5.215)	4.885 (5.086)	3.911 (4.899)	4.427 (4.693)	3.631579 (5.036261)	4.629442 (4.863415)
J459	Cost	30683.1 (18585.5)	39139.1 (20054.9)	30137.5 (14535.8)	58736.4 (126783.9)	30315.03 (15953.47)	52060.41 (103724.6)
	LOS	2.387 (3.685)	2.968 (2.927)	2.253 (2.452)	4.600 (6.209)	2.296651 (2.908845)	4.043956 (5.360166)
N10	Cost	31123.8 (11705.2)	33895.4 (12616.0)	27934.3 (10435.2)	32661.4 (11027.8)	28847.54 (10906.18)	33225.69 (11770.9)
	LOS	5.080 (4.384)	5.972 (4.163)	4.023 (3.766)	6.094 (4.457)	4.325739 (3.980288)	6.038462 (4.316181)
R074	Cost	8416.8 (4153.0)	9962.0 (7355.2)	8379.8 (3880.8)	9813.9 (7180.3)	8399.712 (4029.49)	9898.11 (7278.534)
	LOS	1.028 (1.144)	1.412 (1.640)	1.019 (1.199)	1.439 (1.887)	1.023851 (1.169523)	1.423466 (1.750518)
R101	Cost	12861.7 (5022.1)	20107.9 (18552.9)	13548.1 (9261.8)	16837.8 (15718.9)	13275.15 (7858.973)	18418.96 (17178.18)
	LOS	1.355 (1.864)	2.989 (5.574)	1.524 (2.066)	2.394 (3.217)	1.457115 (1.988899)	2.681319 (4.509975)
R509	Cost	29328.7 (12687.2)	37158.0 (18298.3)	31070.5 (17421.7)	35199.9 (17882.1)	30158.34 (15132.82)	36119.02 (18011.77)
	LOS	3.658 (4.003)	3.348 (3.622)	4.348 (5.288)	4.269 (4.939)	3.986842 (4.665863)	3.836735 (4.373524)
R568	Cost	17908.4 (8290.9)	21637.6 (12275.8)	17244.1 (9224.3)	20340.2 (13902.4)	17630.71 (8694.133)	21153.02 (12881)
	LOS	1.935 (2.266)	2.894 (4.081)	2.293 (2.557)	2.855 (4.721)	2.084323 (2.397237)	2.879518 (4.3174)

Standard deviation in parentheses

The total cost variations between the alcoholic and non-alcoholic groups explained above were also found to be true for both female and male patients (table4.3 and table 4.4). The remarkable point here is that it was due to female patients that the treatment cost of the

unspecified asthma (J459) diagnosis was very high for the alcoholic group when compared to the non-alcoholic group. The female alcoholic patients had an average cost of NOK 58,736.4 (SD = 126,783.9), which very high when compared to the average treatment cost for non-alcoholic female patients (NOK 30,137.7; SD = 14,535.8). This huge difference among the female groups was found to be due to outliers. Two female patients with very high cost of treatment (NOK 358,004 and NOK 958,940) affected both average treatment cost and its standard deviation. However, even after the outliers were excluded, the mean cost (38433.19) and standard deviation (20150.55) for the alcoholic group were found to be higher than that of the non-alcoholic group.

As table 4.3 and table 4.4 show, the average treatment cost for non-alcoholic men and women were not that much different from one another. For instance the diagnoses like A46, R101, and R509, the average hospital treatment cost for female patients were slightly higher than that of male; whereas the rest of the diagnosis, the average hospital treatment cost for men was slightly higher than that of women. The highest cost variation between the two gender groups being N10, which men had treatment cost of NOK 3189.6 more than women.

The average treatment cost of the alcoholic group was not also that much different between men and women except for the unspecified Asthma (J459). Hospital treatment cost for female identified as an alcoholic based on diagnostic history had NOK 19597.4 and NOK 526.7 more than male (also identified as alcoholic) for treatment of the unspecified Asthma (J459) and Erysipelas (A46). All other six diagnosis male treatment cost was higher than female treatment cost (table 4.3; table 4.4). While the inter-group-gender comparison of average treatment cost showed only slight differences within each group category, except J459; the intra-group-gender comparison between the two groups had showed immense difference. This applies to all of the 8 specific conditions and both for men and women.

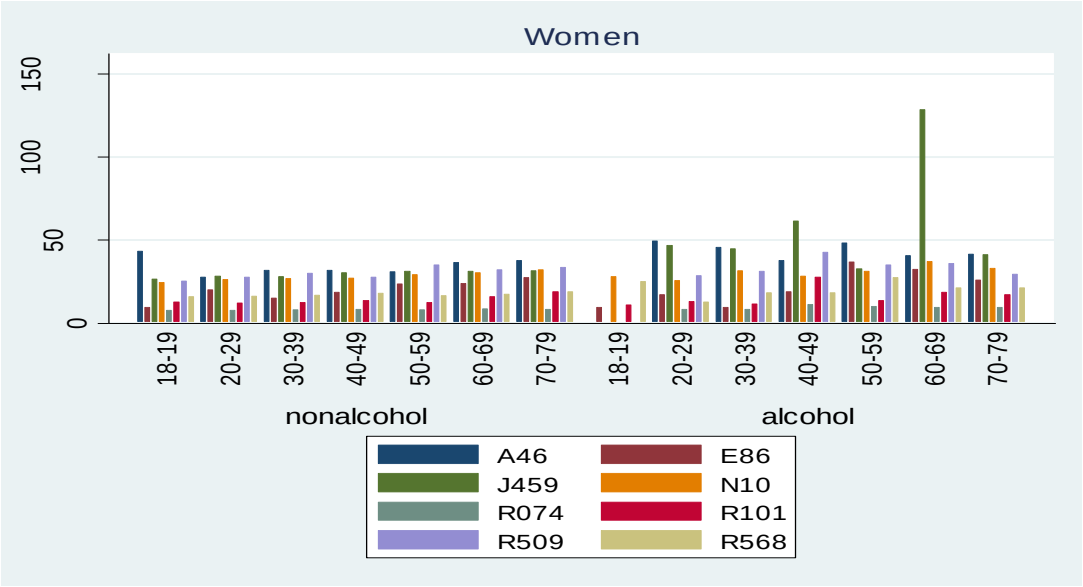
The four figures (4.2 – 4.5) below, the alcoholic group is depicted on the right side of the graph whereas the non-alcoholic group is depicted on the left side. Age and gender were depicted on x-axis. The comparison was within or between the right and left sides of the figures by gender/age-group, and same specific disease diagnosis. In order to understand better whether age factor was influencing the average hospital treatment cost variation between and among the groups in table 4.3 and table 4.4, a graphical representation for mean cost was depicted in figure 4.2 for women and figure 4.3 for men.

Table 4-4: Mean Cost and LOS difference between and among groups presented in table 4.3

	Table 4.3 Column		(1) **A46**	(2) **E86**	(3) **J459**	(4) **N10**	(5) **R074**	(6) **R101**	(7) **R509**	(8) **R568**
Both Gender										
Alcohol – Non-alcohol		Cost	8216.8	7643.7	21745.4	4378.2	1498.4	5143.8	5960.7	3522.3
	(6) – (5)	LOS	1.436	0.998	1.747	1.713	0.400	1.224	-0.150	0.795
		N	2575	596	718	1858	12664	1208	478	1008
Female										
Alcohol – Non-alcohol		Cost	7907.6	5066.5	28598.9	4727.2	1434.0	3289.7	4129.4	3096.1
	(4) – (3)	LOS	1.509	0.517	2.347	2.071	0.420	0.869	-0.0788	0.562
		N	946	345	483	1286	5795	712	233	414
Male										
Alcohol – Non-alcohol		Cost	8387.2	10776.9	8456.0	2771.6	1545.2	7246.2	7829.3	3729.2
	(2) – (1)	LOS	1.386	1.653	0.580	0.892	0.384	1.633	-0.310	0.960
		N	1629	251	235	572	6869	496	245	594
Alcohol Group										
Female – Male		Cost	526.7	-7519.0	19597.4	-1234.0	-148.1	-3270.1	-1958.1	-1297.5
	(4) – (2)	LOS	0.473	-0.458	1.632	0.123	0.0277	-0.595	0.921	-0.0394
		N	255	197	91	234	1679	182	98	166
Non-alcohol Group										
Female – Male		Cost	1006.3	-1808.6	-545.6	-3189.6	-36.92	686.4	1741.8	-664.4
	(3) – (1)	LOS	0.350	0.679	-0.134	-1.056	-0.00877	0.169	0.690	0.358
		N	2320	399	627	1624	10985	1026	380	842

A46 – Erysipelas; E86 – Volume depletion; J459 – Asthma, unspecified; N10 – Acute tubulo-interstitial nephritis; R074 – Chest pain, unspecified; R101 – Pain localized to upper abdomen; R509 – Fever, unspecified; R568 – Other and unspecified convulsions

Figure 4-2: Women Average treatment cost (in terms of 1000 NOK) by age group in 2008



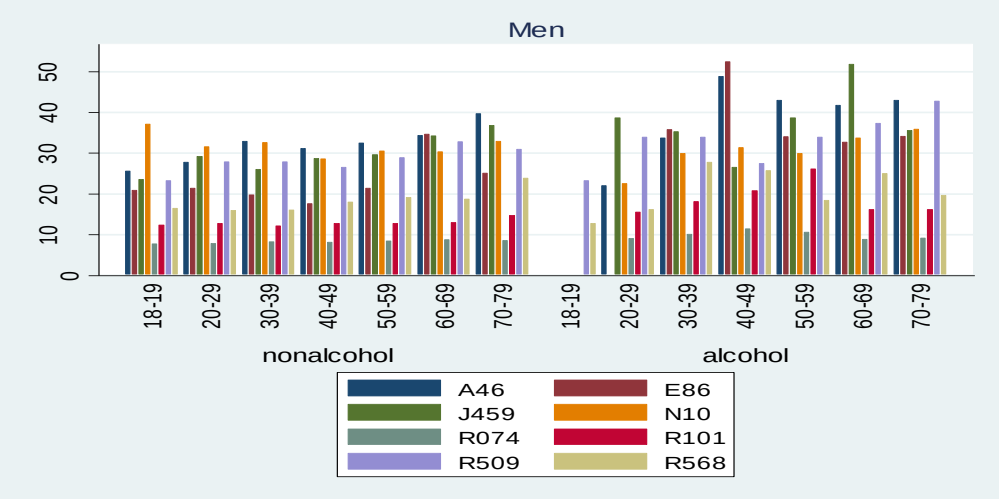
A46 – Erysipelas; E86 – Volume depletion; J459 – Asthma, unspecified; N10 – Acute tubulo-interstitial nephritis; R074 – Chest pain, unspecified;R101 – Pain localized to upper abdomen; R509 – Fever, unspecified; R568 – Other and unspecified convulsions

As mentioned before age was categorized into seven groups in the descriptive statistics. The age factor was depicted on the x-axis while the mean cost was depicted on the y-axis. With exception of the unspecified chest pain (R074), all age-groups of women had close and slight different average treatment cost for both within age-groups and between the age-groups. The within-age-group variation was high for the unspecified asthma (J459), and volume depletion (E86) diagnoses of the alcoholic group. As the figure 4.2 shows, alcoholic female of age-group 60 – 69 had relatively the highest average treatment cost for the unspecified asthma. This indicates that the results shown on table4.3 and table 4.4 for unspecified asthma was heavy affected by the age factor, and the outlier effect mentioned before happens between 60 – 69 age group of the female patients. The age-group 40 – 49 had also higher average treatment cost for unspecified asthma (J459) than other age-groups. In case of volume depletion diagnosis, average treatment cost was relatively low for younger age-groups of 18 – 19 and 20 – 29 than for other older age-group categories. For this diagnosis, the youngest age-group (18 – 19) had the lowest average treatment cost.

A similar pattern was found in men's hospital treatment cost, except for the unspecified asthma. This is shown in figure 4.3 below. The view of the two figures, figure 4.2 and figure 4.3, which look like different should not be confused. It is only the scaling of the two figures that differ. This was caused by the outlier effect of unspecified asthma treatment cost for females of 60 – 69 years old. Other than this, male treatment cost was similar to that of the

female treatment cost. Age-groups 40 – 49 and 60 – 69 had higher average treatment cost for some of the diagnoses (A46, E86, and J459).

Figure 4-3: Men average treatment cost (in terms of 1000 NOK) by age group in 2008



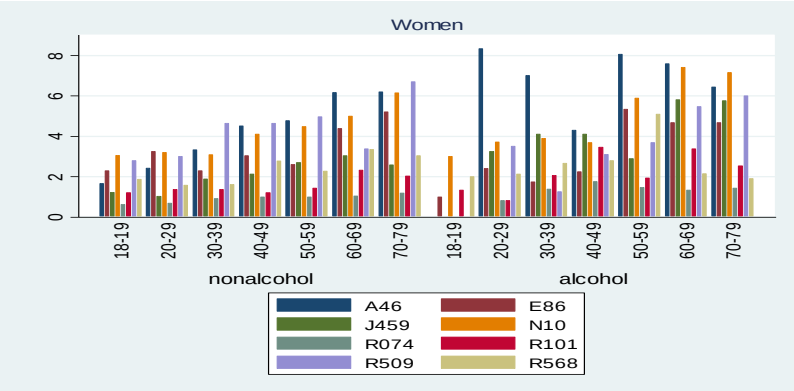
A46 – Erysipelas; E86 – Volume depletion; J459 – Asthma, unspecified; N10 – Acute tubulo-interstitial nephritis; R074 – Chest pain, unspecified;R101 – Pain localized to upper abdomen; R509 – Fever, unspecified; R568 – Other and unspecified convulsions

The cross comparison of the average treatment cost between the alcoholic and non-alcoholic group in both women and men, indicate that the alcoholic group had higher average treatment cost than the non-alcoholic group for all of these diagnoses. Simple mean comparison for the treatment cost differences and variations explained above is not enough to conclude whether the alcoholic group's higher treatment cost matters (strength of the differences); it is important to control outliers and assess the significance of these variations.

4.6.2 Descriptive Statistics for LOS

So far it was described only the variations from the cost perspectives. And as mentioned above the main variables of interest was not only the cost but also the length of stay (LOS). In addition to table 4.3 and table 4.4, the average LOS by gender and age-group are also presented in figure 4.4 and figure 4.5 for women and men respectively. As table 4.3 and table 4.4 indicate, the mean variation of LOS between the two groups was small for all diagnoses with the highest variation being unspecified asthma (J459) and Acute tubulo-interstitial nephritis (N10) diagnoses. In these two diagnoses, the alcoholic group had 1.747 and 1.713 longer LOS than the non-alcoholic group respectively (Table 4.4). Table 4.4 also indicates that women had longer LOS for most of the diagnoses than men for both alcoholic and non-alcoholic group.

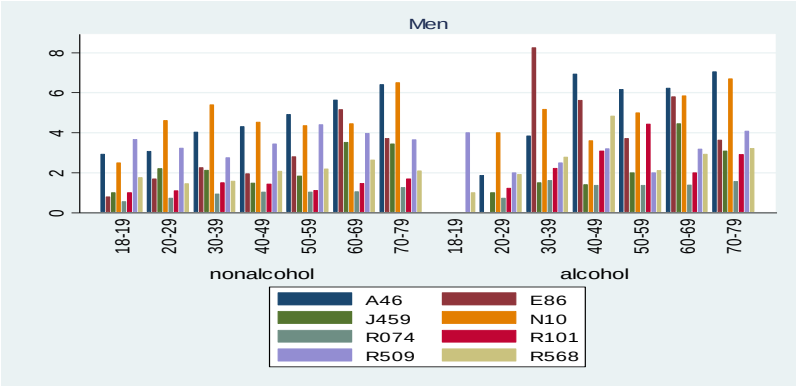
Figure 4-4: Women's average length of stay for 8 selected specific diagnoses by age-group in 2008



A46 – Erysipelas; E86 – Volume depletion; J459 – Asthma, unspecified; N10 – Acute tubulo-interstitial nephritis; R074 – Chest pain, unspecified;R101 – Pain localized to upper abdomen; R509 – Fever, unspecified; R568 – Other and unspecified convulsions

The average LOS variations between men and women within same group and diagnosis were small. However, variations between alcohol and non-alcohol groups among the women groups were bigger than variations among men groups for diagnoses like erysipelas (A46), unspecified asthma (J459) and acute tubulo-interstitial nephritis (N10). Moreover the outlier effect for unspecified asthma (J459) treatment cost of the alcoholic females as mentioned several times before, was not detected in case of LOS.

Figure 4-5: Men's average length of stay for 8 selected specific diagnoses by age-group in 2008



A46 – Erysipelas; E86 – Volume depletion; J459 – Asthma, unspecified; N10 – Acute tubulo-interstitial nephritis; R074 – Chest pain, unspecified;R101 – Pain localized to upper abdomen; R509 – Fever, unspecified; R568 – Other and unspecified convulsions

The two figures (figure 4.4 and figure 4.5) show great average variations of LOS (in days) among and between different age-groups. While it is difficult to conclude from the figures that the older the patient is the longer the LOS, yet the age-groups above 40 years old seem to have longer average LOS than those younger age-groups for both alcohol and non-alcohol

groups. The variations were wider and more complex for the alcoholic group than for the non-alcoholic group.

The above descriptive statistics indicate the need for developing an appropriate statistical method in order to approximate the necessary parameters, and deal with group specific characteristics like gender and age-groups. The following section explains the models and statistical parameters applied in the study.

4.7 Model

The preceding descriptive statistics can not be used to conclude cost and LOS variations between the two groups. These kinds of descriptive statistics do not measure the errors and significance level. Neither do they give a clear picture of what kind of model appropriate for analyzing. In the previous sections it was mentioned that the data was observational data in which the two groups (i.e. the alcohol group – those with alcohol related diseases and non-alcohol group – those without alcohol related diseases) were to be compared.

As mentioned in the previous sections the main explanatory variable "the alcohol factor" is categorical. Age and gender variations were also considered. Gender factor was applied separately for female and male observations; in other words the model was applied separately for male and female observations. The advantage of the separate regression is that it is easier to capture the cost and LOS variations of the two groups (Alcohol vs Non-alcohol) among the same gender. A combined model, where the variations between male and female were tested, is presented in the appendix-A.I. The age-groups were not evenly distributed; in some cases empty cells or very small cells for some age-groups were encountered; this can be observed from figures 4.2, 4.3, 4.4, and 4.5. Because of this problem age was categorized into two groups i.e. young (18 – 49) and old (50 – 79). This means the two explanatory variables (alcohol and age factor), which were both dummy variables, were applied in the model of the main result analysis. The non-alcoholic (those without alcohol co-morbidity) and the young age-group (18 – 49) were taken as the reference category. The regression results with seven age-groups are presented in appendix A.IV, the possibility of empty cells has to be taken into consideration when interpreting the results in appendix A.IV.

The two variables of interest cost and LOS shared these explanatory variables, however, the two variables had different nature; therefore, two different models were applied for cost and LOS. The model frame and specification for LOS and cost and LOS is explained below.

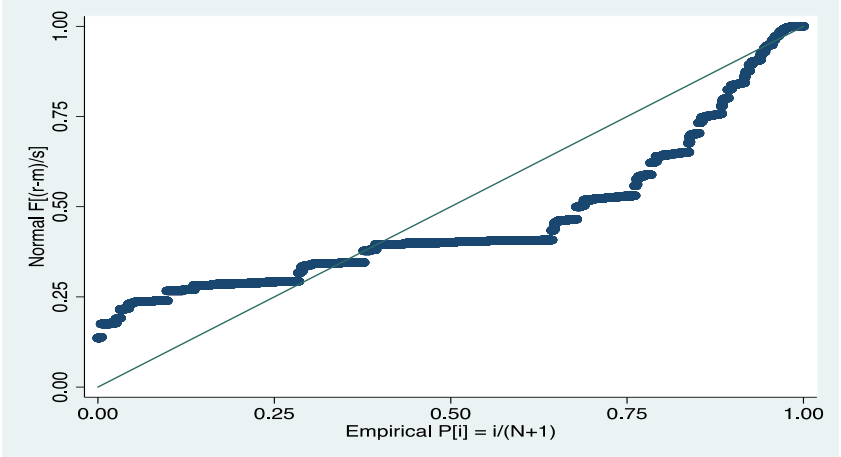
4.7.1 Length of Hospital Stay (LOS)

The length of stay (LOS), measured in days, is a variable of interest in the literature of epidemiology (Lechman and Duder, 2009) particularly in health economics. The cost of a particular disease, among other things, depends on LOS. Estimation of average LOS says something about the expected cost behavior. In theory longer LOS means higher cost and shorter LOS means lower cost (Northcott and Llewellyn, 2003). Each additional day a patient spends in hospital beds costs more. Therefore LOS becomes an important health indicator (Ravangard et al., 2011). When searched in PubMed the term "length of hospital stay" resulted in more than 60,000 findings. How long do patients identified as alcoholic (based on alcohol co-morbidities) spend in hospital treatment for other diagnosis (unknown the association of alcohol)? This was the focal point of this study; and the LOS of 8 specific diagnoses not usually considered for alcohol cost estimation was selected and included in the analysis. Two groups alcoholic and non-alcoholic patients, who were treated with same diagnosis, were compared.

4.7.1.1 Model Framework for LOS

The nature and distribution of the dependent variable usually determines what kind of model to be applied. As table 4.3 displays, LOS was a discrete count variable (i.e. LOS = 0, 1, 2 ….i). Whether patients remained in hospital bed for the same diagnosis or for a different condition were not discoverable. It was assumed that patients stayed in hospital for the treatment of same diagnosis. Patients stayed less than 24 hours were also included as zero. The distribution of the data was tested using different methods, like histogram; kernel density estimate; pnorm; and Shapiro-Wilk W test ($p<0.001$). The normality assumption was unable to accept.

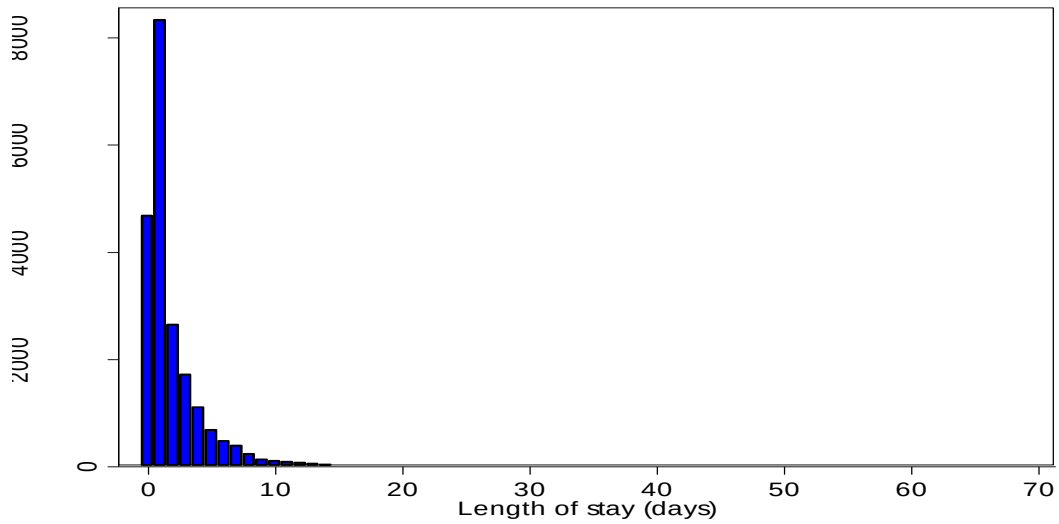
Figure 4-6: The normality distribution test for LOS



The nature of the dependent variable limits the normality of the residuals; the observational data with nonnegative integer outcome (the count data) is usually skewed heavily to right and nonlinear because of its discrete positive integer values (Cameron and Trivedi, 1999; Lord and Park, 2010). One of the common features and structures in health economics and many other applied fields is the count nature data; like number of days patients stayed in hospital or number of patients treated or dead. Models for count data are widely applied for such kind of data (Greene, 2008).

After careful exploration of the alternative distributions of the LOS variable, a Poisson data distribution was the closest distribution. All the 8 diagnoses included in this study follow similar pattern as the aggregate histogram below. The graphical distribution of LOS for each diagnosis is presented in appendix (A.V).

Figure 4-7: The length of stay distribution



According to Greene (2008) the Poisson models are the foundation for almost all count models' framework, but its restrictive assumption of equality between variance and mean confines the applicability of this type of model other count models are mostly favored, like the negative binomial model. The integration of the observed and unobserved variance variations and the conditional means (Park, 2005) is the main motive why the later model was preferred. Moreover, although the structure of the above graph and the nature of the data (count data) fit with Poisson distribution; the assumption of the Poisson distribution of equal mean and variance was violated as indicated in the table 4.3 above. The presence of overdispersion (α) was tested using the $\chi 2$ of the likelihood ratio (LR) test and the null

hypothesis of α = 0 were rejected in all models. A negative binomial model was chosen as an appropriate method of analyzing and dealing with the overdispersion.

4.7.1.2 Model Specification for LOS

The negative binomial model formulas for count data are derived from the Poisson model function (Cameron and Trivedi, 1999):

$$f\ (y|\lambda)\ =\ \frac{exp(-\lambda)\lambda^{y}}{y!} \qquad (4.1)$$

$$\lambda =\ \mu\upsilon, \qquad \upsilon\ >\ 0$$

And a density function g(ν|α)

Where y is the count variable of poison distribution (the length of stay measured as 0 1 2 3 4…) conditional random parameters λ; μ is the deterministic function of the explanatory variables X_i (like age and alcohol consumption in this case); and ν is random part of the unobserved heterogeneity of λ.

By integrate out ν Cameron andTrivedi (1999) derived the following negative binomial regression:

$$h(y|\mu,\alpha) = \frac{\Gamma(y+\alpha^{-1})}{\Gamma(\alpha^{-1}\,)}\left(\frac{\alpha^{-1}}{\alpha^{-1}+\mu}\right)^{\alpha^{-1}}\left(\frac{\mu}{\alpha^{-1}+\mu}\right)^{y}\ ,\ \alpha>0, \qquad (4.2)$$

$$With\ E[y|\mu,\alpha]=\mu;\ and\ V[y|\mu,\alpha)=\ \mu(1+\alpha\mu)$$

Where α is the overdispersion; Γ(.) is the gamma function of the probability distribution. The negative binomial distribution fit with Poisson distribution if α=0. The ordinary binomial regression considers zero outcomes; but this could be a problem if there are excess zeros. The variable LOS had zero value, and was not excluded from the data; a zero value for LOS means patients were treated for these specific diseases but not hospitalized. A Vuong test was applied to test if the ordinary negative binomial model was appropriate. The test compares a zero-inflated negative binomial with the ordinary negative binomial. The Vuong test results were negative and small t-value (|t|<|1.96|), which means an asymptotically distributed standard normal. In other words the Vuong test indicated indifference between the two models, either of these two models could be applied (Vuong, 1989).

Negative binomial regression was used to analyses the variations of LOS between the two groups. Heteroscedasticity was also detected and due to sample size differences heterogeneity of variance between the two groups was assumed. The robust standard error was calculated to

control for heteroscedasticity. Interaction terms was also tested between alcohol related co-morbidities and age-category; no significant interaction factor was discovered and therefore, the interaction factor is removed from the analysis.
The model was applied separately for female (table 5.3) and male (table 5.5) observations However, LOS variation between female and male was tested by adding the gender factor to the model; the result is presented in appendix A.I -Table 8-1.

4.7.2 Hospital Treatment Cost

Cost is one of the two main variables of interest in this paper. The hospital cost is calculated based on Diagnosis Related Groups (DRGs). Norway partly finances somatic hospital treatment cost by DRGs system since 1997 (CHRISTENSEN et al., 2004) to control cost and improve hospital productivity and efficiency (Mishra et al., 2001). DRG is a fixed per-case payment system usually made in prospective payment on hospital admission (OTA, 1983). Its formulation is based on LOS and inputs required for treatments to group of homogeneous patients (Fetter et al., 1980; Street et al., 2012). This system standardizes the hospital treatment cost for patients with identical diagnosis and character. The estimation of cost using DRGs might overestimate or underestimate the actual cost incurred (Mishra et al., 2001). In this study, it was intended to check whether hospital cost was consistent to the findings of LOS; and to emphasize variations between alcoholic (those with alcohol co-morbidities) and non-alcoholic (those without such co-morbidities).

4.7.2.1 Model Framework for Cost

Health care costs are commonly known with the heavily skewedness to right; when this is the case, the ordinary least square (OLS) parameters are not best estimators (Diehr et al., 1999; Buntin and Zaslavsky, 2004). The nonnegative nature of the outcome variable and the presence of few heavy users are confining the applicability of the symmetrical distribution models (Cantoni and Ronchetti, 2006). There are other models which health economists prefer to apply when assumptions like normality is violated; among them are the log transformation method and the generalized linear regression model (GLM). Log transformation is a method of producing the log of the dependent variable before OLS is applied; while log transformation reduces the skewness, deals with outliers, and approximates to a normal distribution of the health care costs (Diehr et al., 1999; Buntin and Zaslavsky, 2004), the log coefficients are not a convenient way of transmitting the results of the health care costs (Buntin and Zaslavsky, 2004). Therefore, retransformation of the log coefficient by using a smearing factor to normal scaling coefficients of mean and variance is usually

required (Buntin and Zaslavsky, 2004). This process is complex and data is usually lost on the way (Buntin and Zaslavsky, 2004). For this reason an alternative method called generalized linear regression model first developed by Nelder and Wedderburn in 1972 (Fox, 2008) is commonly preferred and widely applied in health care cost analysis. The GLM coefficients presented in exponential way helps to avoid the retransformation of coefficients to the original non-log scale; instead it is directly interpretable by using a multiplicative method (Buntin and Zaslavsky, 2004).

When regression diagnoses was applied to cost data of all the 8 diagnoses; as usual the presence of heavily right-skewed distribution was found (Appendix-A.V). Besides that, other assumptions of ordinary linear regression were not violated. The normality distribution was not able to get even after log transformation of the cost. The generalized linear regression model was chosen, to give a picture of cost comparison between those with alcohol co-morbidities and those without alcohol co-morbidities. Moreover, variations of the significance level were found between models with robustness and those without robustness. This implies the presence of heteroscedasticity. Modified Park Test was applied to determine the GLM family distribution (Manning and Mullahy, 2001); and as suggested by Cantoni andRonchetti (2006), a combined model of GLM (gamma family) and robust approach was used to deal with these issues.

4.7.2.2 Generalized Linear Regression Model Specification for Cost

According to Fox (2008) generalized linear model specification is based on three main parts:

i. The conditional distribution of the outcome variable Y_i is determined by a random component belonging to the exponential families, in this case cost had gamma family distribution.

ii. A linear predictor (In this paper X_i are dummy variables and linear prediction is not important)

$$\eta_i = \alpha + \beta_1 X_{i1} + \beta_2 X_{i2} + \cdots + \beta_k X_{ik} = \boldsymbol{X_i'\beta}$$

iii. And a conditional mean link function g(.) for the transformation of the outcome variable, $\mu_i = E(Y_i)$ into a linear predictor

$$g(\mu_i) = \eta_i = \boldsymbol{X_i'\beta} \Rightarrow called\ the\ mean\ function: g^{-1}(\eta_i) = \mu_i.$$

With log link

$$log\big(E(Y_i/\boldsymbol{X}_i)\big) = \boldsymbol{X_i'\beta} \Rightarrow E(y_i/\boldsymbol{X}_i) = e^{\boldsymbol{X_i'\beta}}$$

Where y is dependent variable (cost) and x_i represents the explanatory variables like alcohol (based on alcohol related co-morbidity), gender, and age-category.

And relationship between mean and variance

$$Var[Y_i/X_i] = \phi\mu_i^v$$

Where ϕ is the dispersion parameter; v determines what kind of GLM family is suitable. If v = 0 a Gaussian, v = 1 a Poisson, v = 2 a Gamma, and if v = 3 an Inverse Gaussian or Wald family. Modified Park Test applied indicated that v ~= 2; and there GLM with gamma family was applied. A gamma distribution which has two parameters scale $\omega > 0$ and shape $\psi > 0$

$P(y) = \left(\frac{y}{\omega}\right)^{\psi-1} \times \frac{\exp\left(\frac{-y}{\omega}\right)}{\omega\Gamma(\psi)}$ for $y > 0$, where $\Gamma(.)$ is the gamma function, ψ is the shape parameter, and ω is the scale parameter. The two parameters scale and shape deals with spread and skewness issues respectively. The GLM with gamma distribution has $E(Y) = \omega\psi$ and $V(Y) = \phi\mu^2$. Where the dispersion term ϕ is equal to $1/\psi$ (Fox, 2008).

This GLM was applied separately for female (table 5.4) and male (table 5.6) observations as for NBR model. However, cost variation between female and male was tested by adding the gender factor to the model; the result is presented in appendix A.I -Table 8-2.

4.7.3 Statistical Methods

Statistical analyses were computed using Stata data analysis and statistical software packages (Stata/SE 10.1; Stata/MP 11.1 and Stata/SE 12). Simplified tables were created using the user command option estout developed by Jann (2007). The conventionally applied p-value of less than 5% was used to reject the null hypothesis of zero coefficients; however, lesser p-values like 1% and 0.1% were also marked, to emphasize the higher level of significance. The coefficient output of negative binomial regression and generalized linear regression model were in log scale. However, the log scale is not a convenient way to interpret the results. The log scale was transformed into an exponential coefficient scale (rate ratio). The percentage change of the dependent variables expressed as $(e^{\beta} - 1)*100\%$ was also used to interpret the coefficients. Both univariate and multivariate analysis was performed, but only multivariate analysis was reported, because no surprises were found variations between univariate and multivariate analysis.

5. Results Analysis for LOS and Cost

The summary statistics by gender, age-group and alcohol factor displayed in table 5.1 and table 5.2 were applied to NBR for LOS and GLM regression for cost respectively. These two tables provide the mean and the standard deviation of length of hospital stay (LOS) and hospital treatment cost. The results of these tables were merely intended to add what had been discussed in previous section of descriptive statistics. What distinguishes these summary statistics in table 5.1 and table 5.2 from previous descriptive statistics is that age was classified as young (18 – 49) and old (50 – 79) as for the regression models for LOS and cost. The summary statistics in these two tables can be observed the individual characteristics which the two models were applied to compare. As the tables 5.1 and 5.2 indicate the majority of the diagnoses, the alcoholic group had Longer LOS and higher cost, but there are cases which the non-alcoholic group had longer LOS and higher cost.

The variations of group means were tested using negative binomial regression (NBR) for LOS and generalized linear regression model (GLM) for cost as explained in the previous section. The NBR and GLM compares the group means classified in table 5.1 and table 5.2 below respectively. The regression was applied separately for male and female as mentioned before. This was done to find a simple way of testing mean variations among group within same gender. In this way the females of different age-groups and alcohol factor (Alcoholic vs Non-alcoholic) were compared. Mean variation between male and females were also tested and presented in the appendix-A.I.

Results of each gender groups were presented separately. Table 5.3 and table 5.4 below provide exponentiated coefficients of NBR for LOS and GLM for cost respectively for women observations. Table 5.5 and table 5.6 below provide the exponential coefficients for LOS and cost for men observations. Statistical significance between the two groups was found. Although the results of the regression for all of the 8 diagnoses were displayed together, the findings of each diagnosis were computed and explained separately.

Table 5-1: The mean and standard deviation of LOS by gender and age

			Mean & standard deviation of LOS							
Gender	**Age**	**Group**	**A46**	**E86**	**J459**	**N10**	**R074**	**R101**	**R509**	**R568**
		Non-alcohol	3.979	1.833	1.843	4.678	0.960	1.346	3.198	1.700
			(4.504)	(1.788)	(2.261)	(4.703)	(1.135)	(1.845)	(4.014)	(1.800)
	18 – 49	*n*	619	54	89	121	2,695	237	86	300
		alcohol	4.821	6.500	1.375	4.417	1.370	2.488	3	3.204
			(4.877)	(5.600)	(1.302)	(2.353)	(1.524)	(4.659)	(1.936)	(5.370)
Male		*n*	28	12	8	12	230	41	9	49
		Non-alcohol	5.555	3.918	2.809	5.221	1.084	1.368	4.009	2.305
			(5.137)	(6.138)	(4.452)	(4.264)	(1.147)	(1.894)	(3.976)	(2.817)
	50 – 79	*n*	851	110	115	344	3,219	171	113	190
		alcohol	6.588	4.627	3.522	6.168	1.425	3.426	3.432	2.618
			(4.689)	(4.991)	(3.146)	(4.306)	(1.677)	(6.282)	(3.941)	(2.446)
		n	131	75	23	95	725	47	37	55
Female		Non-alcohol	3.744	2.859	1.768	3.338	0.932	1.324	4.103	2.021
			(3.707)	(4.408)	(2.020)	(2.989)	(1.093)	(1.856)	(5.113)	(2.456)
	18 – 49	*n*	234	85	220	739	1,555	413	87	233
		alcohol	5.176	2.071	3.957	3.676	1.590	2.174	2.688	2.559
			(4.066)	(1.730)	(5.448)	(2.266)	(2.535)	(3.951)	(2.774)	(2.776)
		n	17	14	23	34	122	46	16	34
		Non-alcohol	5.810	4.507	2.778	5.229	1.057	1.927	4.574	2.824
			(6.163)	(5.075)	(2.758)	(4.602)	(1.242)	(2.391)	(5.462)	(2.676)
	50 – 79	*n*	616	150	203	420	3,516	205	94	119
		alcohol	7.089	4.771	5	6.978	1.409	2.604	4.972	3.214
			(6.453)	(4.891)	(6.679)	(4.734)	(1.727)	(2.331)	(5.532)	(6.379)
		n	79	96	37	93	602	48	36	28

Standard deviation in parenthesis; n- number of observations

Table 5-2: Mean & standard deviation of Cost by age-category and gender

Gender	Age	Group	A46	E86	J459	N10	R074	R101	R509	R568
		Non-alcohol	31236.3	19527.7	27704.0	30318.4	8164.4	12545.9	27070.2	16639.6
			(17639.8)	(12934.3)	(12291.6)	(12908.1)	(2726.9)	(5228.1)	(8020.6)	(7587.1)
	18 – 49	*N*	619	54	89	121	2695	237	86	300
		Alcohol	37985.1	46853.4	30282.3	29945.8	11033.3	19063.9	29198.1	22866.2
			(21164.9)	(52892.7)	(9643.4)	(5467.0)	(9873.2)	(13453.2)	(5674.7)	(14748.2)
		N	28	12	8	12	230	41	9	49
Male										
		Non-alcohol	34975.1	26978.8	32988.7	31407.1	8628.0	13299.4	31047.5	19911.9
			(31315.1)	(30880.8)	(22049.3)	(11258.0)	(5036.8)	(4701.7)	(15127.6)	(8954.9)
	50 – 79	*N*	851	110	115	344	3219	171	113	190
		Alcohol	42600.7	33454.1	42219.7	34394.3	9622.1	21018.6	39094.2	20543.0
			(17792.8)	(26541.8)	(21918.5)	(13181.1)	(6322.4)	(22176.7)	(19791.1)	(9565.9)
		N	131	75	23	95	725	47	37	55
Female		*Non-alcohol*	31382.3	17472.7	28999.1	26388.1	8244.1	12666.9	28383.4	17066.1
			(14052.7)	(11200.0)	(14566.7)	(8906.3)	(3643.3)	(5106.8)	(11121.0)	(10249.9)
	18 – 49	*N*	234	85	220	739	1555	413	87	233
		Alcohol	40455.6	14900.8	52518.6	28788.0	10350.6	17247.7	38084.2	17496.4
			(18899.1)	(8991.2)	(70667.1)	(7390.4)	(8754.0)	(21511.8)	(29603.8)	(6808.5)
			17	14	23	34	122	46	16	34
		Non-alcohol	35556.0	25688.4	31371.3	30654.8	8439.9	15323.3	33557.5	17592.6
			(19198.1)	(17376.8)	(14436.7)	(12231.2)	(3980.3)	(14213.9)	(21449.4)	(6808.4)
	50 – 79	*N*	616	150	203	420	3516	205	94	119
		Alcohol	42714.7	29661.9	62601.6	34077.5	9705.1	16445.0	33918.0	23793.2
			(28962.2)	(21039.5)	(152485.7)	(11806.5)	(6820.9)	(6747.1)	(9212.1)	(18906.5)
		N	79	96	37	93	602	48	36	28

Standard deviation in parenthesis; n- number of observations

5.1 Erysipelas (A46)

As shown in table 4.1, 2,575 patients, who were registered in Norwegian Patient Registry (NPR) of 2008 for erysipelas treatment, were included in this study. While almost half of these patients spent one day at hospital, yet there were patients who spent as much as 60 days for treating the same diagnosis. 2,320 of these patients were non-alcoholic patients and the rest (255) were alcoholic patients (based on diagnostic history). Though the number of alcoholic group admitted for erysipelas was much less than non-alcohol group, the average LOS was longer and the mean cost was higher for the alcoholic group than for the non-alcoholic group. The longer LOS and higher cost were also true for women and men as well as both age-groups as shown in table 5.1 and table 5.2 respectively.

Average length of treatment (in days) comparison in table 5.1 also shows that the older the individual the longer was the LOS for alcoholic group. This applies for both women and men. For instance as table 5.1 shows Age-group(18 – 49) had an average LOS(days) 5.2 (sd = 4.1) for women, and 4.8 (sd = 4.9) for men; whereas Age-group(50 – 79) had higher average LOS (days) 7.1 (sd = 6.5) and 6.6 (sd = 4.7) with the corresponding gender. The cost pattern was also similar as shown in table 5.2. However, the big standard deviation makes such kind of comparison less reliable.

The negative binomial regression and generalized linear regression model explained in the model section above were presented in table 5.3 and table 5.4 for women, and table 5.5 and table 5.6 for men. The first column of the table 5.3, table 5.4, table 5.5 and table 5.6 were presented exponentiated coefficients of the NBR and GLM results of LOS and cost for erysipelas treatment. As table 5.3 and table 5.5 (for LOS) and table 5.4 and table 5.6 (for cost) indicate the exponential coefficients of the two explanatory factors (alcohol-group-category, and Age-category) for both genders indicate a positive increase of the LOS as well as cost when compared to the references groups (non-alcohol and Age-group(18 – 49).

In case of LOS, the Wald (χ^2) illustrates that the model for LOS versus the two explanatory variables was statistically significant with $\chi^2 = 41.79$ ($p<0.001$) for women, and $\chi^2= 52.86$ ($p<0.001$) for men (Table5.3; Table 5.5). Since pseudo-R^2 is not a true measure of the explained variance, it was excluded from the results. Instead the predicted and observed LOS of the model was presented in appendix-A.V. Moreover, other things being constant, it was found a slightly longer LOS for the alcoholic group than for the non-alcoholic group. This variation was statistically significant for both women ($\beta= 1.247$(se = 0.121; $p<0.05$) times

longer LOS), and men (β= 1.191(se = 0.0783; p<0.01) times longer LOS). This means that when other factors are kept constant, women of the alcohol group had 24.7% longer LOS days than non-alcoholic women group. The percentage variation is calculated as $(e^{\beta} - 1)*100$.

Table 5-3: The effect of alcohol (alcohol-related diseases) to women's length of hospital stay for 8 diagnoses

Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
LOS	**A46**	**E86**	**J459**	**N10**	**R074**	**R101**	**R509**	**R568**
alcohol♥	1.247*	1.005	1.960***	1.272***	1.395***	1.489*	0.935	1.206
	(0.121)	(0.127)	(0.355)	(0.0862)	(0.0734)	(0.241)	(0.168)	(0.244)
Age♥								
50 – 79	1.536***	1.675**	1.522***	1.592***	1.102**	1.408**	1.220	1.372**
	(0.112)	(0.278)	(0.157)	(0.0805)	(0.0406)	(0.148)	(0.194)	(0.165)
_cons	3.773***	2.746***	1.798***	3.316***	0.952	1.341***	3.915***	2.035***
	(0.234)	(0.422)	(0.137)	(0.107)	(0.0287)	(0.0898)	(0.494)	(0.160)
Wald(χ^2)	41.79***	9.80***	33.05***	122.97***	58.99***	26.16***	1.62	6.98
df	2	2	2	2	2	2	2	2
LR(α=0)♣	1711***	626***	370***	735***	317***	288***	503***	261***
N	946	345	483	1286	5795	712	233	414

Exponentiated coefficients; robust standard errors in parentheses (se); ♣ Likelihood-ratio test of alpha=0
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
♥ Reference groups are those without alcohol-related co-morbidity; age-group 18 – 49
A46 – Erysipelas; E86 – Volume depletion; J459 – Asthma, unspecified; N10 – Acute tubulo-interstitial nephritis; R074 – Chest pain, unspecified;R101 – Pain localized to upper abdomen; R509 – Fever, unspecified; R568 – Other and unspecified convulsions

The age factor had also a positive effect with longer LOS for the old age-group of both genders. The old women had more than 50% longer LOS than the young women. This huge difference between age groups of women was found to be statistically significant (1.536 times longer: se = 0.11; p<0.001). Differences of LOS between the age-groups among the men was also high as 40% longer LOS for the old men than for young of the same gender. Again the variation among the age-men-groups was significant. The exponentiated coefficients of LOS shown in table 5.5 indicates that old men had 1.394 (se = 0.0745; p<0.001) times longer LOS than the reference age – group.

The GLM regression results (table 5.4 and table 5.6) were consistent with the negative binomial regression for both genders as well as the two age-categories. The mean treatment cost of erysipelas diagnosis (A46) for young female (18 – 49), which had no alcohol-related co-morbidities, was NOK 31507.4 (se = 902.2). However, other things being equal, the mean treatment cost of erysipelas diagnosis for young alcoholic female patient (those with alcohol related co-morbidities) was 1.217 (se = 0.0820; p<0.01) times higher than young female

patients without alcohol co-morbidities (table 5.4). As shown in table 5.6, the effect of alcohol factor on the treatment cost of erysipelas diagnosis (A46) for male patient was similar to that of the female. Small, but significant positive effect of the age factor was found both among men and women. When other things are kept constant, the old age-group (50 – 79) had 12.7% ($p<0.001$) for female and 12% ($p<0.01$) for male higher average treatment cost than the young age-group of the respective gender (Table 5.4 and Table 5.6)

Table 5-4: The effect of alcohol (alcohol-related diseases) for female treatment cost of 8 selected diagnoses

Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Cost	**A46**	**E86**	**J459**	**N10**	**R074**	**R101**	**R509**	**R568**
alcohol	1.217**	1.101	1.921*	1.105**	1.169***	1.219	1.120	1.163
	(0.0820)	(0.0904)	(0.513)	(0.0350)	(0.0330)	(0.134)	(0.101)	(0.0980)
Age								
50 – 79	1.127***	1.547***	1.094	1.164***	1.016	1.169*	1.116	1.079
	(0.0397)	(0.124)	(0.0761)	(0.0252)	(0.0147)	(0.0750)	(0.0829)	(0.0560)
_cons	31507.4	16915.6	28841.6	26372.8	8288.5	12815.0	29258.2	16808.2
	(902.2)	(1104.6)	(1202.1)	(320.9)	(96.97)	(273.2)	(1286.1)	(643.6)
Log LH♣	-10846.5	-3821.9	-5503.99	-14468.0	-58258.8	-7504.4	-2649.3	-4462.63
N	946	345	483	1286	5795	712	233	414

Exponentiated coefficients; robust standard errors in parentheses (se)
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
♣ LH = Log likelihood
♥ Reference groups are those without alcohol-related co-morbidities; age-group 18 – 49
A46 – Erysipelas; E86 – Volume depletion; J459 – Asthma, unspecified; N10 – Acute tubulo-interstitial nephritis; R074 – Chest pain, unspecified;R101 – Pain localized to upper abdomen; R509 – Fever, unspecified; R568 – Other and unspecified convulsions

5.2 Volume Depletion (E86)

596 patients, who were admitted for treating volume depletion, were recorded in NPR in 2008 (table 4.1). Most of these patients were hospitalized for at least one day. 399 patients were identified as non-alcoholic of which 235 were women, and 164 were men; whereas 197 patients were identified as alcoholic patients (patients with alcohol-related co-morbidities), 110 women; and 87 men (table 4.1).

As table 4.3 and table 4.4 indicate, the alcoholic group had longer length of hospital stay (LOS), and higher treatment cost than for the non-alcoholic. The alcoholic group had an average LOS of 4.885 days (sd = 5.086) for men, and 4.427(sd = 4.693) days for women. However, the non-alcoholic group had a lower average LOS of 3.232 days (sd = 5.215), and 3.911 days (sd = 4.899) for men and women respectively. Table 5.1 indicates also longer LOS

for both age-groups of men, but this was not true for women age-groups. The young women age-group (18 – 49), who were alcoholic, had shorter LOS (2.071; sd = 1.73) than non-alcoholic women (2.859, sd =4.408) of the same age-group. The average hospital treatment cost also follows the similar pattern (table 4.3, table 4.4 and table 5.2).

To assess the strength and significance of these variations, a negative binomial regression (NBR) with robust option was applied for LOS. The result of NBR is displayed in the second column of table 5.3 for women, and table 5.5 for men. As in the case of the erysipelas, the predictors (alcohol and age factor) significantly explain the variation of LOS for the volume depletion treatment between the alcohol and non-alcohol group. Other things being constant, the alcoholic men had 48% longer LOS than non-alcoholic men, this longer LOS for the alcoholic men was found significant at 5% level (1.48 times longer: se = 0.227; $p<0.05$). However this was not the case for women observations. No statistically significant difference was found between alcoholic and non-alcoholic women. While age factor had higher positive effect over the reference age-group, LOS variation between the age-groups was longer among the women than among the men. Ceteris paribus, the old women had 67.5% ($p < 0.01$) longer LOS than the young women; whereas the old men had 52.3% ($p<0.05$) longer LOS than the young men.

GLM regression results on hospital treatment cost for the volume depletion were consistent with NBR when it comes to the effect of the alcohol factor (table 5.4 and table 5.6). The non-alcoholic male patients had an average treatment cost of NOK 21970.2 (se = 2280). But male patients who were identified as an alcoholic patients (based on diagnostic history) had 1.421 (se = 0.192; $p<0.01$) times higher cost than non-alcoholic male patients. However, as the NBR for LOS, the cost variations between alcoholic and non-alcoholic female patients were small and not significant at 5% level. The effect of age factor was also different between male and female models. For instance, the mean cost of volume depletion treatment for young non-alcoholic female (18 – 49) was NOK 16915.6 (se = 1104.6). However, ceteris paribus, the old female patients (50 – 79) had 1.547 (s = 0.124; $p<0.001$) times higher treatment cost than young female had (table 5.4). Age factor had no significant effect among males (table 5.6).

5.3 Unspecified Asthma (J459)

718 patients, who were treated for unspecified asthma diagnosis, were registered in NPR of 2008. 91 of them were identified as alcoholic, and 627 were non-alcoholic. 60 Out of the 91 alcoholic patients were women and 31 were men. Whereas 423 out of the 627 non-alcoholic

were women, and 204 were men (table 4.1). Table 4.3, table 5.1 and table 5.2 also present the average (mean) LOS and treatment cost of unspecified asthma for both women and men.

Although the average length of hospital stay for alcoholic group was longer than the corresponding non-alcoholic for both genders, no statistically significant difference was found between the two groups among the men observations. However, other things being constant, the women, who were identified as alcoholic stayed 96% longer LOS for treatment of the unspecified asthma than other non-alcoholic women. This is 1.96 (se = 0.355; $p<0.001$) times longer LOS. The age factor was found to have a strong statistically significant effect for both genders. The old age-group had 52.2% (i.e. 1.522 times longer; se = 0.157; $p<0.001$), and 60.1% (i.e. 1.601 times longer; se = 0.290; $p<0.01$) longer LOS for women (table 5.2) and men (table 5.4) respectively.

The cost regression results displayed in table 5.4 for women and table 5.6 for men indicates statistically significance effect of the alcohol factor for both male and female models. Contrary to the NBR result of LOS for male observations, which was not found any significance effect of the alcohol factor, the GLM regression result of cost for male was found statistically significant. The average treatment cost of unspecified asthma for the alcoholic male was 1.228 (se = 0.119; $p <0.05$) times higher than the non-alcoholic male. In case of female model, the GML regression result was consistent to the NBR result. Both models as shown in table 5.3 and table 5.4 indicate strong effect of the alcohol factor for LOS and cost. The average cost for the non-alcoholic female was NOK 28841.6 (se = 1202.1), whereas the alcoholic female had 1.921 (se = 0.513; $p<0.05$) times this amount. In the previous section of descriptive statistics, it was mentioned that an outlier effect was involved for the treatment cost of unspecified asthma for alcoholic female observations. While the GLM deals with outliers in general, relatively extreme outliers could affect the result. However, even after the outlier observations were excluded, there was higher treatment cost for the alcoholic than for than non-alcoholic females; but only 1.253 (se = 0.0940; $p<=0.01$) times higher (result not shown). Age factor had higher treatment cost for old, and was significant only for male model (table 5.4; table 5.6).

5.4 Acute Tubulo-interstitial Nephritis (N10)

In 2008, 1858 patients, who were treated from acute tubulo-interstitial nephritis (ATIN) diseases, were included in the NPR. 234 of these patients were also diagnosed with alcohol-related diseases and identified as alcoholic group, while the rest (1,624 patients) were not

diagnosed such diseases related to alcohol. Out of the 234 alcoholic patients, 127 were female and 107 were male (table 4.1).

As the table 4.3 and table 4.4 indicate, longer average LOS and higher treatment cost for the alcoholic group was found for both genders. The longer LOS for the alcoholic was not common for both young and old among men. The young non-alcoholic male had little longer average LOS and higher cost than the young alcoholic men (table 5.1; table 5.2). The LOS variations between alcoholic and non-alcoholic, young and old among men were insignificant (table 5.5). But it is important to mention that the two explanatory factors were not found significant for explaining the variation of LOS of the male model ($\chi^2(2) = 5.75$, $p>0.05$). This means the model was not well explained by these two factors.

Contrary to the male model, the LOS variation among the women was found statistically significant. A Wald chi-square of 122.97 with 2 degree of freedom signifies this at 5% level (table 5.3). Moreover, the longer average LOS in the descriptive tables was strengthened by the NBR result shown in table 5.3. The length of hospital stay for ATIN treatment of the alcoholic women was 1.272 (se = 0.0862; $p<0.001$) times longer than that of the non-alcoholic women. This means, other things being constant, there were 27.2% longer LOS for the alcoholic than non-alcoholic among the women. LOS variations between the old and young women were also found to be significant. Other things being equal, the old women had 1.592 (se = 0.0805, $p<0.001$) times longer LOS than the young women.

Although the LOS variation between alcoholic and non-alcoholic among male was not found statistically significant, the GLM regression results indicate that alcoholic (those patients with alcohol-related co-morbidity) had higher statistically significant treatment cost of ATIN than non-alcoholic for both male (table 5.6) and female (table 5.4) models. However, only 10.5% higher in case of female model (table5.4) and 8.1% higher for case of male model (table 5.6). The age factor was statistically significant for female model only, which the older female had 16.4% higher treatment cost than younger female.

5.5 Unspecified Chest Pain (R074)

Another diagnosis of interest which is not usually included when quantifying alcohol-attributable fraction of economic loss is the unspecified chest pain. As the name suggests it is a type of chest pain not known the causes behind. This diagnosis had the largest sample size among the diagnoses selected to compare the treatment cost and length of stay between the alcoholic group and non-alcoholic group.

There were 12,664 patients, who were treated from unspecified chest pain, were included in the registry of NPR in 2008 (table 4.1). More than 86% of these patients were identified as non-alcoholic group, whereas only 13% of them were identified as alcoholic group. While as other diagnoses, the alcoholic group had smaller sample size than the non-alcoholic group, it has the largest sample size (1,679) for all diagnoses among the alcoholic group. 955 out of the 1679 alcoholic group were men while the rest, about 724, were women.

The average LOS for all patients was shorter than 2 days and slightly longer for the alcoholic group (table 4.2, table 5.1). The two explanatory variables significantly explain the over all model for both men ($\chi^2(2) = 75.75$, $p<0.001$) and women ($\chi^2(2) = 58.99$, $p<0.001$). Though the variations between the two groups (the alcoholic and non-alcoholic) was small, shorter than a half day, it was statistical significant for both genders.

Table 5-5: The effect of alcohol (alcohol-related diseases) to men's length of hospital stay for 8 diagnoses

Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
LOS	**A46**	**E86**	**J459**	**N10**	**R074**	**R101**	**R509**	**R568**
alcohol♥	1.191**	1.480*	1.125	1.152	1.342***	2.174***	0.874	1.475*
	(0.0796)	(0.249)	(0.227)	(0.0890)	(0.0544)	(0.451)	(0.149)	(0.231)
Age♥								
50 – 79	1.394***	1.526*	1.601**	1.142	1.117***	1.089	1.239	1.221
	(0.0745)	(0.265)	(0.290)	(0.106)	(0.0313)	(0.150)	(0.183)	(0.128)
_cons	3.982***	2.347***	1.789***	4.598***	0.966	1.307**	3.219***	1.777***
	(0.177)	(0.307)	(0.225)	(0.395)	(0.0212)	(0.118)	(0.407)	(0.107)
Wald(χ^2)	52.86***	20.68***	8.89*	5.75	75.75***	14.52***	2.73	17.85
df	2	2	2	2	2	2	2	2
LR(α=0)♣	2059***	494***	239***	494***	172***	366***	310***	295***
N	1629	251	235	572	6869	496	245	594

Exponentiated coefficients; robust Standard errors in parentheses (se); ♣ Likelihood-ratio test of alpha=0
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
♥ Reference groups are those without alcohol-related co-morbidities; age-group 18 – 49
A46 – Erysipelas; E86 – Volume depletion; J459 – Asthma, unspecified; N10 – Acute tubulo-interstitial nephritis; R074 – Chest pain, unspecified;R101 – Pain localized to upper abdomen; R509 – Fever, unspecified; R568 – Other and unspecified convulsions

The exponentiated coefficients of the negative binomial regression (NBR) in table 5.3 and table 5.5 indicate that, other things being constant, treatment of the unspecified chest pain was 1.395 (se = 0.0734; $p<0.001$) times longer LOS for the alcoholic women, and 1.342 (se = 0.0544; $p<0.001$) times longer for the alcoholic men than for the non-alcoholic women and men respectively. This was 39.5% and 34.2% longer LOS for alcoholic women and men. The NBR results also indicate that the LOS variation among the age-groups was statistically significant with slightly longer LOS for the old age-group for both genders.

The descriptive statistics in table 4.4 and table 5.2 also indicate minor variations of treatment cost between the alcoholic and non-alcoholic for both genders. As table 4.4 indicates, on average alcoholic had extra NOK 1434 for female and NOK 1545.2 for male than non-alcoholic of the corresponding gender. The GLM regression results in table 5.4 and table 5.6 show that these small variations between the two groups were significant. The model indicates that the alcoholic female had 1.169 (se = 0.0330; p<0.001) times higher cost than the non-alcoholic female (table 5.4). As table 5.6 indicates, the effect of alcohol factor on male model was similar to that of the female model. The age factor had a very small positive effect for both female and male models, and it was significant at 5% level only for male model.

Table 5-6: The effect of alcohol (alcohol-related diseases) for men treatment cost of 8 selected diagnoses

Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Cost	**A46**	**E86**	**J459**	**N10**	**R074**	**R101**	**R509**	**R568**
alcohol	1.218***	1.421**	1.228*	1.081*	1.177***	1.551***	1.218*	1.197**
	(0.0529)	(0.192)	(0.119)	(0.0425)	(0.0302)	(0.150)	(0.0932)	(0.0740)
Age								
50 – 79	1.120**	1.164	1.210**	1.047	1.035**	1.068	1.169**	1.136**
	(0.0408)	(0.165)	(0.0869)	(0.0413)	(0.0135)	(0.0492)	(0.0594)	(0.0454)
_cons	31234.5	21970.2	27453.7	30081.8	8259.8	12508.8	26777.2	16984.5
	(695.0)	(2280.0)	(1241.9)	(1087.1)	(60.25)	(360.0)	(823.8)	(439.2)
Log LH♣	-18630.4	-2819.12	-2669.44	-6498.78	-69110.9	-5228.22	-2775.36	-6429.56
N	1629	251	235	572	6869	496	245	594

Exponentiated coefficients; robust standard errors in parentheses(se)
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
♣ LH = Log likelihood
♥ Reference groups are those without alcohol-related co-morbidities; age-group 18 – 49
A46 – Erysipelas; E86 – Volume depletion; J459 – Asthma, unspecified; N10 – Acute tubulo-interstitial nephritis; R074 – Chest pain, unspecified;R101 – Pain localized to upper abdomen; R509 – Fever, unspecified; R568 – Other and unspecified convulsions

5.6 Pain Localized to Upper Abdomen (R101)

There were 1208 patients, of whom 1026 were non-alcoholic and 182 were alcoholic, were registered in NPR for treatment of upper abdominal pain in 2008 (table 4.2). The LOS and cost variations for the treatment of 94 women and 88 men of the alcoholic group were compared to 618 women and 408 men of the control group respectively. The descriptive statistics displayed in table 4.2, table 4.4, table 5.1 and table 5.2 indicate that there was longer LOS and higher treatment cost for the alcoholic patients than for the non-alcoholic patients for both male and female, and young and old.

The two explanatory variables significantly explained the negative binomial regression model (NBR) for women with $\chi^2(2) = 26.16$ ($p<0.001$) (table 5.3) and men $\chi^2(2) = 14.52$ ($p<0.001$) (table 5.5). Moreover, the coefficients of the alcohol factor for both female and male models were significant. When other things are kept constant, the alcoholic women had 1.489 (se = 0.241; $p<0.05$) times longer LOS than the non-alcoholic women, whereas the alcoholic men had 2.174 (se = 0.451; $p<0.001$) times longer LOS than the non-alcoholic men. This means there were 48.9% longer LOS for the alcoholic women and 117% longer LOS for the alcoholic men when compared to the corresponding non-alcoholic groups. The extreme variations among the men group were not understood. While there was longer average LOS for the alcoholic men, nothing outstanding (like extreme outliers) was discovered. Besides, the age factor was not found statistically significant in men's model. In women's model; ceteris paribus, the old women had 1.408 (se = 0.148; $p<0.01$) times longer LOS than the reference age-group (the young women).

The cost variations for pain localized to upper abdomen was consistent with LOS for male. The GLM regression result in table 5.6 indicates that the treatment cost for the alcoholic men was 1.551 (se = 0.150; $p<0.001$) times higher than the treatment cost for non-alcoholic men (NOK 12508.8, se = 360). But the cost variation was not big as LOS variation among male. The cost variations among the female was not found significant at 5% level. The age factor had positive effect for both genders and it was significant amongst females only.

5.7 Unspecified Fever (R509)

While unspecified fever is not life threatening condition by itself to the adults, the underneath conditions causing the fever could be. Therefore, patients are sometimes hospitalized when figuring out what is causing for the fever. 478 patients, whom were admitted in public hospitals in Norway during 2008, were recorded in NPR. 98 of these patients, of whom 52 were men and 46 were women, were also treated from alcohol related diagnoses, and therefore identified them as alcoholic group (table 4.1).

The Average LOS of hospitalization for the treatment of the unspecific fever diagnosis was slightly longer for the non-alcoholic group than for the alcoholic group for both age-groups of men and the young age-group of women (table 4.3, table 4.4, and table 5.1). The negative binomial regression tests indicate also longer LOS for the non-alcoholic group than for the non-alcoholic group. However, neither alcohol nor age factor were found statistically significant at 5% level (table 5.3; table 5.5).

Contrary to the shorter LOS for the alcoholic than for the non-alcoholic, the treatment cost of the unspecified fever was higher for the alcoholic for both female and male (table 4.3; table 4.4; table 5.2). Moreover, the GLM regression result for male model indicates statistically significant higher treatment cost for the alcoholic male (table 5.6). The old male also had higher treatment cost of the unspecified than young male, with 1% level of significance. However, in case of female model, neither alcohol nor age factor was found statistically significant (table 5.4).

5.8 Unspecified Convulsions (R568)

1008 individuals, who were accepted in hospital care during 2008 for the treatment of unspecified convulsions and recorded in NPR, were included in the analysis. As other diagnoses above, smaller sample size for the alcoholic group was found. There were only 166 patients, who in addition to the unspecified convulsion, were treated from diseases related to alcohol as well. 104 of them were male and 52 were female (table 4.1). A comparison of LOS and cost variations between those treated from alcohol related illness and those who were not diagnosed with such illness was made separately for female and male.

Table 4.3, 4.4, 5.1 and table 5.2 were displayed the mean and standard deviation of cost and LOS for both genders. The later two tables include age factor as well. The results displayed in table 5.1 and table 5.2 show that there were longer LOS and higher cost of treatment for those patients who were identified as alcoholic (also treated from the alcohol-related diseases) for both genders.

The NBR results also indicate that, other things being constant, there was 47.5% and 20.6% longer LOS for the alcoholic men and women respectively than for the non-alcoholic men and women (table 5.3; table 5.5). However, only the variations among men groups were found statistically significant at 5% level of significance (1.475 times longer: SE = 0.231; $p<0.05$). The effect of the age factor was found significant among the women. When other things are kept constant, the old women had 1.372 (se = 0.165; $p<0.01$) times longer LOS than the young women. The cost regression results in table 5.4 and table 5.6 indicate the higher treatment cost for the alcoholic patients was not significant at 5% level among the females, but it was significant at 1% level among males. The old age-group had higher treatment cost for both genders, but again it was found statistically significant only for male model.

6. Discussion

Economic loss due to alcohol consumption is estimated to be substantial throughout the world, yet there are difficulties of capturing the true fraction of economic loss attributable to alcohol consumption (Baumberg, 2006). This is mainly due to the multiple risk factors and complex causation model. In addition, little evidence about the relationship between cost behavior of many diseases and harms and some risk factors (alcohol in this case), which are not directly related to the causation of the specific diseases in question, complicate the cost estimation methods. Even though the risk factor (alcohol in this case) may not be related directly to the occurrence of the disease, but it might indirectly affect the treatment process.

In order to develop proper policy response to the risk factors, finding the true societal cost is an important engine. The main objective of this study was to enlighten and observe whether there is a cost aspect, which is not commonly taken into consideration when estimating the economic cost of alcohol. It was compared two groups of patients (Alcoholic – those with alcohol co-morbidity and non-alcoholic – those without alcohol-related diseases). The hospital treatment cost and the length of hospital stay (LOS) of 8 diagnoses were analyzed. The case group, which was the group identified as an alcohol consumers based on diagnostic history (patients with alcohol co-morbidity), was compared to a control group (patients without alcohol-related diseases).

Both the descriptive statistics as well as the regression results indicated longer LOS and higher treatment cost for the alcoholic group for all diagnoses except the unspecified fever. Five out of the eight diagnoses analyzed in this study were found statistically significant longer LOS for patients identified with history of alcohol-related diagnoses for both women and men. Diagnoses like erysipelas (A46), unspecified asthma (J459), acute tubule-interstitial nephritis (N10), unspecified chest pain (R074), and pain localized to upper abdomen (R101) had statistically significant longer LOS for women with alcohol-related diagnoses than women without these diagnoses (table 5.3). Men identified as alcoholic (based on alcohol-related diagnoses) were found to have longer LOS for diagnoses like erysipelas (A46), volume depletion (E86), unspecified chest pain (R074), pain localized to upper abdomen (R101), and other unspecified convulsion(R568) than men who were assumed to be non-alcoholic (table 5.5). Three of these diagnoses were found significant for both women and men. However, variation of LOS was wider among the women than among the men for two the diagnoses of erysipelas (A46) and unspecified chest pain (R074). The variation of LOS for

pain localized to upper abdomen (R101) was relatively wider among males than among the females.

The generalized linear regression model for treatment cost was consistent with the findings of LOS variation. Statistically significant higher treatment cost for the alcoholic (those with alcohol-related co-morbidity) was found among the men for all of the 8 diagnoses (table 5.6). Amongst the women, 4 diagnoses, all of which were found significant variation for LOS model, were also found statistically significant higher treatment cost for those with alcohol-related co-morbidity (table 5.4). It was only the pain localized to upper abdomen (R101) diagnosis that cost and LOS models were not consistent among women. Statistically significant cost and LOS variations between females and males were not found except the acute tubule-interstitial nephritis (N10), which males had a little higher treatment cost than females (Appendix-A.I-Table 8-1; Table 8-2).

There are important points that have to be taken under consideration while interpreting the results of this study. The selection process of identifying patients into two groups as well as diagnostic selection suffers selection bias. As explained in the methods and study design section, diagnoses that are fully attributable to alcohol (Appendix-A.II-Table 8.3) as well as those diagnoses that are only partially attributable to alcohol (Appendix-A.II-Table 8.4) were used to identify a patient as an alcoholic (Alcohol co-morbidity). Difficulties in finding observations to compare the two groups were the main reason for including the partially alcohol-attributable diseases. How much these would affect the result of the study is unknown. Moreover, it was difficult to measure the pure effect of alcohol on non-alcohol related diseases since there was no record of drinking habit. The use of alcohol-related co-morbidity as a means to distinguish patients says more about the effect of co-morbidity rather than alcohol. However, a sensitivity analysis (applying only the 100% alcohol-attributable diagnoses in table 8.3 for distinguishing the two groups) was done on unspecified chest pain (R074) diagnosis. This diagnosis had 57 observations for those with pure alcohol-related co-morbidity and 6,812 observations for control group. The result was consistent as shown in the appendix-A.III-table 8.5.

The selection process of the 8 diagnoses analyzed in this study was not also systematic. A minimum observations for the both groups was simply set (n>=100) and applied. This did not hold after collapsing the dataset in order to aggregate the patients with multiple observations. However, while a random and systematic method for diagnostic selection might select

different diagnoses, the fact that these diagnoses included in this study indicated higher treatment cost and longer LOS for alcoholic would not be affected by the selection of any other diagnoses. But again the selection process of these 8 diagnoses was merely a convenient way rather than a random systematic method.

The finding of this study was not based on randomized controlled trail. Cost and time constrained for performing such kind of study. It was rather a retrospective observational data and many important factors (unobservable heterogeneity) that could explain a lot of the variations of the LOS and cost were missing. Smoking, diet, training habit, and genetic and environmental factors are among the most important factors that could have changed the results. Studies indicate that smokers consume more alcohol than non-smokers (Rimm et al., 1995; Reed et al., 2007). Studies also indicate that smoking and alcohol are common risk factors to many diseases (Mukamal, 2006). This means most of the diseases that are partially attributable to alcohol (Table 8-4), which were used for group identification, are also attributable to smoking. Genetic as well environmental factors could also be the cause of the co-morbidities assumed to be alcohol-related diseases. This implies that lifestyle of the individual as well as environmental and genetic factors could have an impact on both the occurrences of the disease as well as the recovering process. Other factors like adverse effects due to misdiagnosis, mistreatment, and treatment side effects were not also available to consider. Moreover, reasons a patient remained in hospital bed were assumed to be for the same specific diagnosis under consideration.

These missing features also called omitted variables, which are individual specific character, were not included in the analysis. Instead, these unobservable heterogeneities were assumed to be random for all patients. This means the study had potential parameter bias known as *unobserved heterogeneity bias*. It was difficult to deal such kind of bias, since these factors were not available it was impossible to include for control. However, in case of the LOS, the negative binomial regression model applied, considers overdispersion by including a random term (ε), and this minimizes unobserved heterogeneity amongst the individuals (Long and Freese, 2006).

Another barrier was lack of enough observations suitable for comparison. The sample size of the case group was relatively very small compared to the control group for all diagnoses considered in this study. The unequal cell size is common to almost all studies including randomized controlled trials. However, in this case it was very wide in some of the diagnoses.

In addition to the problem of unequal variances, this restricted, to further categorize the individual age-groups. Because of the fewer observations of the age-groups below 40 years, age-category was divided only into two groups, that is, below 50 and above 50. This was done to minimize the problem of empty cells. While this categorization helped to execute statistical models, there is high possibility it widened the problem of unobservable heterogeneity. However, a sensitivity analysis of the age category is conducted by dividing the age into seven categories (the results displayed in the appendix A.IV), and no significant changes were observed.

The potential misspecification error of the models could also affect the estimated parameters. Because of the relaxations of the assumptions of the ordinary least square models, the generalized linear regression models' parameter estimations could be inefficient and imprecise compared to the ordinary least square models (Buntin and Zaslavsky, 2004).

While these limitations could affect the variations of LOS and cost analyzed in this study, the importance of the issues raised in this study is incontestable. The under estimation of the economic burden of alcohol could be higher than expected. The need of well organized researches with broader perspective by including more diagnoses under consideration is recommended.

7. Conclusion

Alcohol involves with many diseases as risk factor either wholly or partially (Rehm et al., 2009), the economic loss attributable to alcohol is substantial (Baumberg, 2006; Thavorncharoensap et al., 2009). Yet, there are doubts as to whether the economic cost of alcohol is estimated accurately because of intricate multidimensional associations between alcohol use and health conditions related to it (Rehm et al., 2010). Moreover, alcohol-related diseases co-occur with other non-alcohol-related diseases, which further complicate the treatment and recovering process from both alcohol-related and non-alcohol-related diseases. Co-morbidity of diseases is common and associated with increased health care costs (Fortin et al., 2007a; Fortin et al., 2007b; Valderas et al., 2009). This makes the estimation of economic burden of alcohol even more obscure. It also seems that in cost benefit analysis studies of alcohol, the effect of alcohol to non-alcohol related diseases when co-morbidity happens is not usually considered.

The result of this study indicates that patients with alcohol-related diseases had higher treatment cost with longer length of hospital stay (LOS) for the treatment of the non-alcohol-related diagnoses when compared to other patients who had not alcohol-related diagnosis. If this is the case it means a crucial portion of the economic burden of alcohol is disregarded, implying underestimation of the social cost burden of alcohol. It is difficult to generalize the result of this finding, because of the limitations and important missing factors. However, the findings of this study could be used as benchmark to further investigate and study how alcohol indirectly affects the treatment cost of other non-alcohol related diagnoses. Important factors are always missing from the economic cost estimates of alcohol and other substances abuse (NIAAA, 2000) this necessitates continuous development and reformation of cost estimation methods as well as factor considerations (Single, 2009).

In a nutshell, there are so much that is not yet discovered about the economic and social burden of alcohol. A much broader perspective of the cost estimates and constant researches on alcohol-attributable burden is recommended. Any future research in this area is also recommended to distinguish the effect of alcohol from the effect of co-morbidity.

8. Appendices

A.I. NBR and GLM with gender variable included

Table 8-1: The effect of alcohol (alcohol-related diseases) for the LOS of 8 diagnoses and variation by gender

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
LOS	**A46**	**E86**	**J459**	**N10**	**R074**	**R101**	**R509**	**R568**
alcohol♥	1.209***	1.200	1.665***	1.220***	1.365***	1.786***	0.906	1.368*
	(0.0675)	(0.127)	(0.244)	(0.0626)	(0.0444)	(0.236)	(0.113)	(0.171)
Gender♥								
Female	1.021	1.095	1.054	0.923	0.982	1.064	1.222	1.159
	(0.0418)	(0.117)	(0.111)	(0.0442)	(0.0208)	(0.0900)	(0.129)	(0.0903)
Age♥								
50 – 79	1.436***	1.576***	1.535***	1.466***	1.110***	1.267**	1.230	1.280**
	(0.0620)	(0.199)	(0.141)	(0.0667)	(0.0250)	(0.108)	(0.133)	(0.102)
cons_	3.902***	2.481***	1.743***	3.748***	0.967	1.278**	3.213***	1.768***
	(0.153)	(0.300)	(0.181)	(0.203)	(0.0185)	(0.0955)	(0.331)	(0.108)
N	2575	596	718	1858	12664	1208	478	1008

Exponentiated coefficients; robust standard errors in parentheses
♥ Reference groups are those without alcohol related diagnoses; male; age-group 18 – 49
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 8-2: The effect of alcohol (alcohol-related diseases) for the treatment cost of 8 selected diagnoses

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Cost	**A46**	**E86**	**J459**	**N10**	**R074**	**R101**	**R509**	**R568**
Alcohol♥	1.217***	1.249**	1.679**	1.095***	1.173***	1.371***	1.168*	1.183***
	(0.0449)	(0.101)	(0.329)	(0.0270)	(0.0223)	(0.0997)	(0.0711)	(0.0591)
Gender♥								
Female	1.013	0.868	1.048	0.944**	0.991	1.023	1.045	0.966
	(0.0266)	(0.0636)	(0.0564)	(0.0195)	(0.00943)	(0.0364)	(0.0467)	(0.0327)
Age♥								
50 – 79	1.122***	1.353***	1.128*	1.134***	1.027**	1.125**	1.145**	1.113***
	(0.0302)	(0.112)	(0.0632)	(0.0215)	(0.00995)	(0.0476)	(0.0526)	(0.0358)
_cons	31197.3	20651.2	27604.6	28251.2	8298.9	12513.9	27346.7	17167.4
	(628.0)	(1670.2)	(1529.8)	(625.4)	(58.21)	(317.0)	(842.2)	(431.2)
Log LH♣	-29476.9	-6642.86	-8175.19	-20967.3	-127369.9	-12733.9	-5424.78	-10892.3
N	2575	596	718	1858	12664	1208	478	1008

Exponentiated coefficients; robust Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
♣ LH = Log likelihood
♥ Reference groups are those without alcohol related diagnoses; male; age-group 18 – 49
A46 – Erysipelas; E86 – Volume depletion; J459 – Asthma, unspecified; N10 – Acute tubulo-interstitial nephritis; R074 – Chest pain, unspecified;R101 – Pain localized to upper abdomen; R509 – Fever, unspecified; R568 – Other and unspecified convulsions

A.II. Alcohol attributable diseases used for identification of groups

Table 8-3: Diseases 100% attributable to alcohol consumption, which are used for group identification

ICD-10	Health Condition
F10-F10.9	Mental and behavioral disorders due to use of alcohol
G31.2	Degeneration of nervous system due to alcohol
G62.1	Alcoholic polyneuropathy
G72.1	Alcoholic myopathy
I42.6	Alcoholic cardiomyopathy
K29.2	Alcoholic gastritis
K70	Alcoholic liver disease
K85.2	Alcohol-induced acute pancreatitis
K86.0	Chronic pancreatitis (alcohol induced)
O35.4	Maternal care for (suspected) damage to fetus from alcohol
Q86.0	Fetal alcohol syndrome (dysmorphic)
R78.0	Finding of alcohol in blood
T51.0-T51.1	Ethanol poisoning & Methanol poisoning
T51.8-T51.9	Toxic effect of alcohol, unspecified
Y90	Evidence of alcohol involvement determined by blood alcohol level

Source: (Jones et al., 2009; Rehm et al., 2010)

Table 8-4: Diseases that are partially attributable to alcohol consumption, which are used for group identification

ICD-10	Health Condition
A15-A19, B90	Tuberculosis
B20-B24	Human immunodeficiency virus/acquired immune deficiency syndrome (HIV/AIDS)
C00-C13	Malignant neoplasm of lip, oral cavity and pharynx
C15-C16	Malignant neoplasm of oesophagus
C18-C22	Malignant neoplasm of colon; Malignant neoplasm of rectum; Malignant neoplasm of liver and intrahepatic bile ducts
C33-C34	Trachea, bronchus and lung cancer
C50	Malignant neoplasm of breast
D00-D48	Other neoplasms
E10-E13	Diabetes mellitus
F01-F03;G30,G31	Alzheimer's disease and other dementias
F32, F33, F34.1	Unipolar depressive disorders
G40-G41	Epilepsy and Status epilepticus
I11-I13	Hypertensive heart disease
I20-I25	Ischaemic heart disease
I42	Cardiomyopathy
I47-I48	Conduction disorders and other dysrhythmias
I60-I67;I69.0-I69.3	Ischaemic stroke; Haemorrhagic and other non-ischaemic stroke
J09-J22;J85	Lower respiratory infections: pneumonia
K20–K22, K28–K31, K38, K57–K63, K75.2, K75.3, K75.4, K76–K77, K90–K92 (except K92.0,K92.1, K92.2, K92.9	Other digestive diseases
L40-L41	Psoriasis
O00-O008	Abortion

Source: (Jones et al., 2009; Rehm et al., 2010)

A.III. Only 100% alcohol-attributable disease used for group identification

Table 8-5 : The effect of alcohol (100% alcohol-related diseases) for the LOS for unspecified chest pain among men

	(LOS) R074	(Cost) R074
alcoholcons	1.838***	1.431***
	(0.338)	(0.147)
Age		
50 – 79	1.153***	1.049***
	(0.0322)	(0.0134)
_cons	0.987	8365.4***
	(0.0217)	(70.87)
lnalpha		
_cons	0.164***	
	(0.0271)	
N	6869	6869

Exponentiated coefficients; Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
♥ nonalcohol group; Age group 18 – 49 as reference group
♠ Wholly alcohol-attributable diagnoses were used for identification

A.IV. NBR and GLM Models for seven age groups

Table 8-6: The variations of LOS among seven age groups

LOS	(1) **A46**	(2) **E86**	(3) **J459**	(4) **N10**	(5) **R074**	(6) **R101**	(7) **R509**	(8) **R568**
Alcohol♥	1.186**	1.192	1.599**	1.184***	1.340***	1.778***	0.900	1.331*
	(0.0691)	(0.126)	(0.229)	(0.0606)	(0.0442)	(0.226)	(0.109)	(0.159)
Gender♥								
female	0.999	1.103	1.074	0.956	0.974	1.064	1.214	1.140
	(0.0411)	(0.112)	(0.108)	(0.0448)	(0.0208)	(0.0891)	(0.127)	(0.0879)
age♥								
20 – 29	1.072	1.629	1.142	1.089	1.200	1.090	0.912	0.910
	(0.245)	(0.572)	(0.326)	(0.0987)	(0.167)	(0.171)	(0.275)	(0.160)
30 – 39	1.422	1.700	1.664*	1.127	1.612***	1.256	1.010	1.004
	(0.314)	(0.607)	(0.409)	(0.103)	(0.211)	(0.195)	(0.288)	(0.174)
40 – 49	1.622*	1.798	1.617*	1.358***	1.766***	1.302	1.123	1.504*
	(0.356)	(0.628)	(0.396)	(0.119)	(0.228)	(0.212)	(0.302)	(0.271)
50 – 59	1.830**	1.992*	1.933**	1.461***	1.753***	1.312	1.295	1.356
	(0.396)	(0.643)	(0.471)	(0.127)	(0.226)	(0.218)	(0.335)	(0.242)
60 – 69	2.162***	2.916***	2.715***	1.602***	1.788***	1.710**	1.139	1.655*
	(0.467)	(0.935)	(0.682)	(0.140)	(0.231)	(0.282)	(0.291)	(0.329)
70 – 79	2.290***	2.653**	2.425***	2.019***	2.039***	1.619**	1.429	1.420*
	(0.497)	(0.809)	(0.598)	(0.173)	(0.266)	(0.260)	(0.380)	(0.251)
_cons	2.706***	1.489	1.136	3.143***	0.591***	1.063	3.141***	1.569**
	(0.575)	(0.449)	(0.273)	(0.263)	(0.0754)	(0.150)	(0.746)	(0.257)
lnalpha								
_cons	0.464***	0.746***	0.626***	0.289***	0.197***	0.657***	0.715***	0.495***
	(0.0262)	(0.0658)	(0.0672)	(0.0252)	(0.0206)	(0.0774)	(0.0609)	(0.0573)
N	2575	596	718	1858	12664	1208	478	1008

Exponentiated coefficients; Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

♥ Reference groups are those without alcohol related diagnoses; male; age-group 18 – 19

A46 – Erysipelas; E86 – Volume depletion; J459 – Asthma, unspecified; N10 – Acute tubulo-interstitial nephritis; R074 – Chest pain, unspecified;R101 – Pain localized to upper abdomen; R509 – Fever, unspecified; R568 – Other and unspecified convulsions

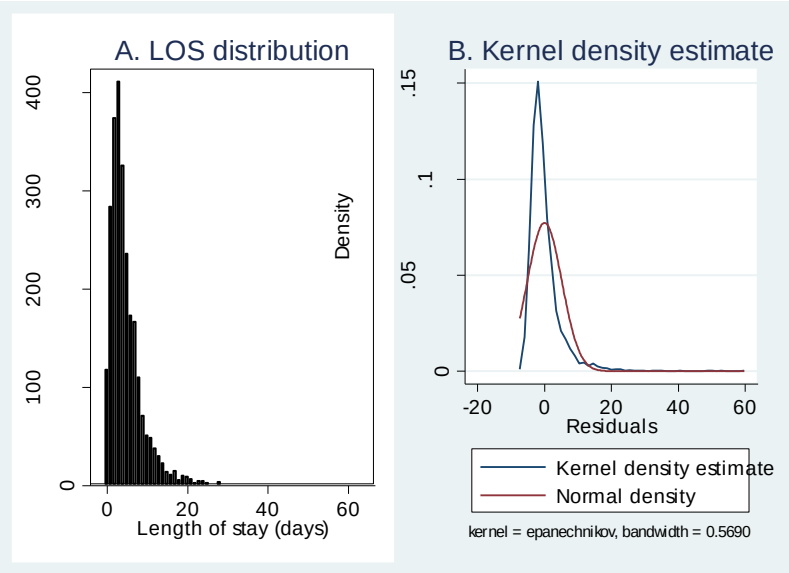
Table 8-7: The treatment cost variation between seven age groups

Cost	(1) **A46**	(2) **E86**	(3) **J459**	(4) **N10**	(5) **R074**	(6) **R101**	(7) **R509**	(8) **R568**
Alcohol♥	1.203***	1.238**	1.629**	1.084**	1.172***	1.352***	1.163**	1.168**
	(0.0476)	(0.0971)	(0.282)	(0.0268)	(0.0222)	(0.0919)	(0.0667)	(0.0590)
Gender ♥								
Female	1.003	0.868*	1.053	0.951*	0.990	1.023	1.045	0.962
	(0.0271)	(0.0604)	(0.0541)	(0.0202)	(0.00937)	(0.0343)	(0.0434)	(0.0327)
Age♥								
20 – 29	0.957	1.495*	1.097	1.048	1.014*	0.984	1.160*	0.986
	(0.0793)	(0.261)	(0.108)	(0.0377)	(0.00650)	(0.0544)	(0.0801)	(0.0715)
30 – 39	1.134	1.263	1.056	1.096*	1.057***	0.987	1.204**	1.061
	(0.0948)	(0.227)	(0.0810)	(0.0448)	(0.0112)	(0.0536)	(0.0707)	(0.0774)
40 – 49	1.104	1.553*	1.153	1.079*	1.088***	1.133	1.178**	1.146
	(0.0891)	(0.294)	(0.111)	(0.0379)	(0.0105)	(0.0769)	(0.0694)	(0.0862)
50 – 59	1.131	1.841***	1.151	1.154***	1.092***	1.068	1.320***	1.141
	(0.0909)	(0.316)	(0.0964)	(0.0445)	(0.00866)	(0.0685)	(0.105)	(0.0846)
60 – 69	1.226*	2.016***	1.392*	1.201***	1.110***	1.164*	1.353***	1.169*
	(0.0978)	(0.363)	(0.180)	(0.0480)	(0.0146)	(0.0862)	(0.0805)	(0.0823)
70 – 79	1.322**	1.893***	1.193*	1.256***	1.087***	1.291*	1.341***	1.284**
	(0.120)	(0.293)	(0.104)	(0.0486)	(0.0126)	(0.134)	(0.0814)	(0.103)
_cons	28718.3***	14570.7***	25079.8***	26433.0***	7769.2***	12196.9***	23388.3***	16243.4***
	(2208.8)	(2214.6)	(2122.6)	(1031.0)	(34.24)	(672.1)	(925.5)	(1047.4)
N	2575	596	718	1858	12664	1208	478	1008

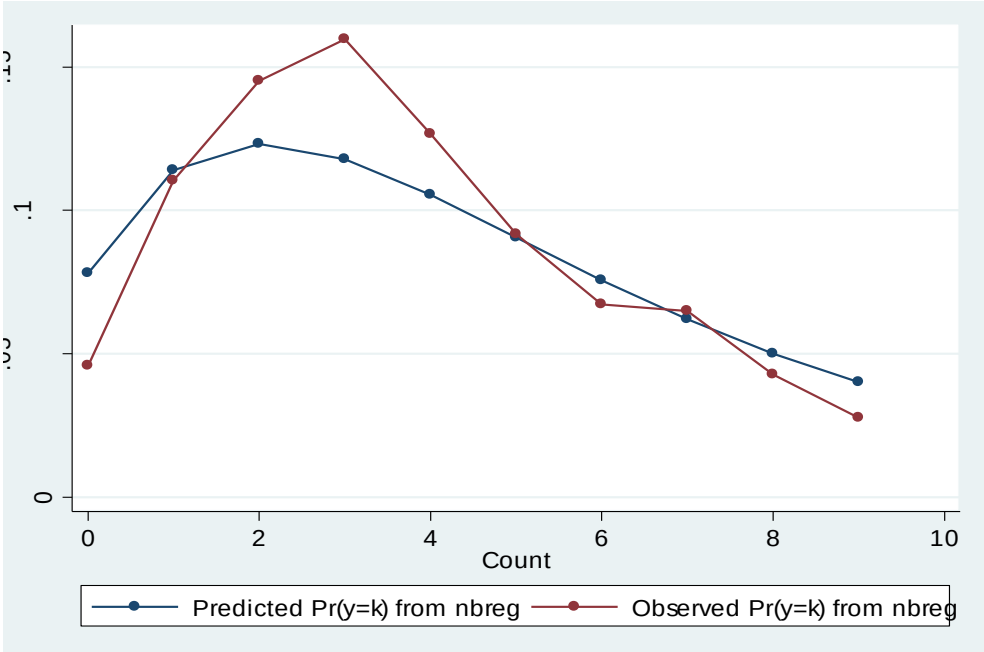
Exponentiated coefficients; Standard errors in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; ♥ Reference groups are those without alcohol related diagnoses; male; age-group 18 – 19

A.V. Normality and Distribution

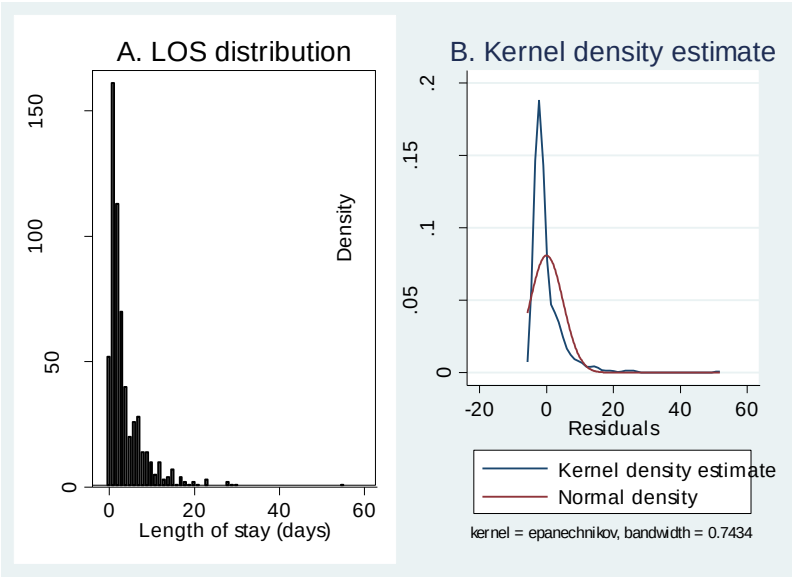
The length of hospital stay distribution and residuals normality for Erysipelas diagnosis



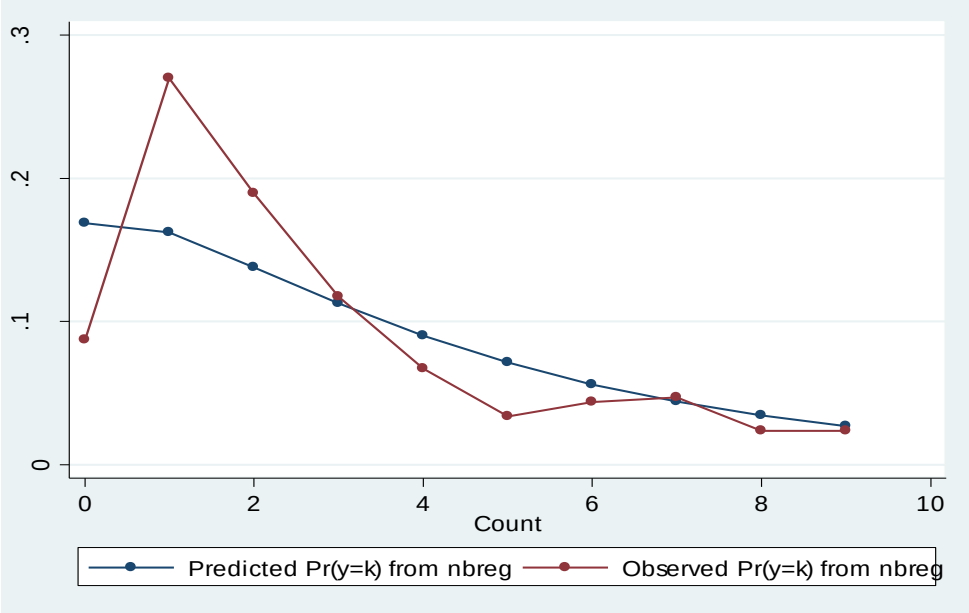
The model prediction for erysipelas



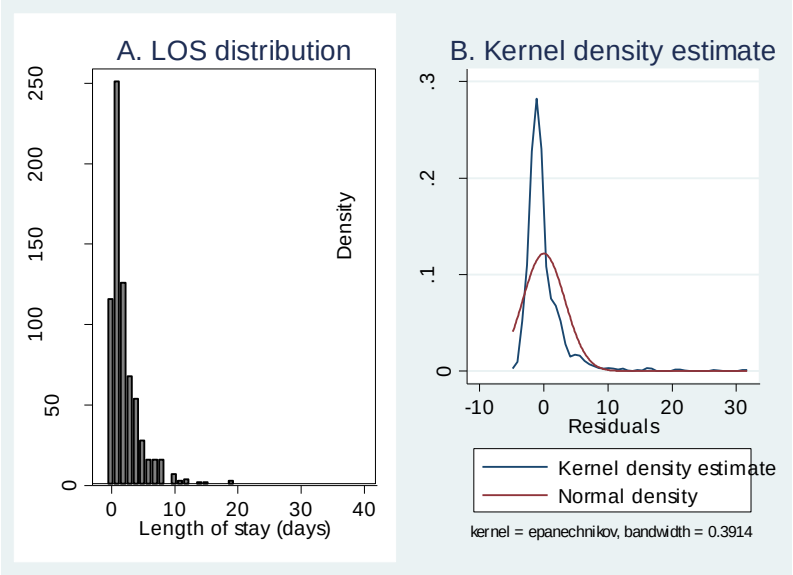
The length of hospital stay distribution and residuals normality for volume depletion diagnosis



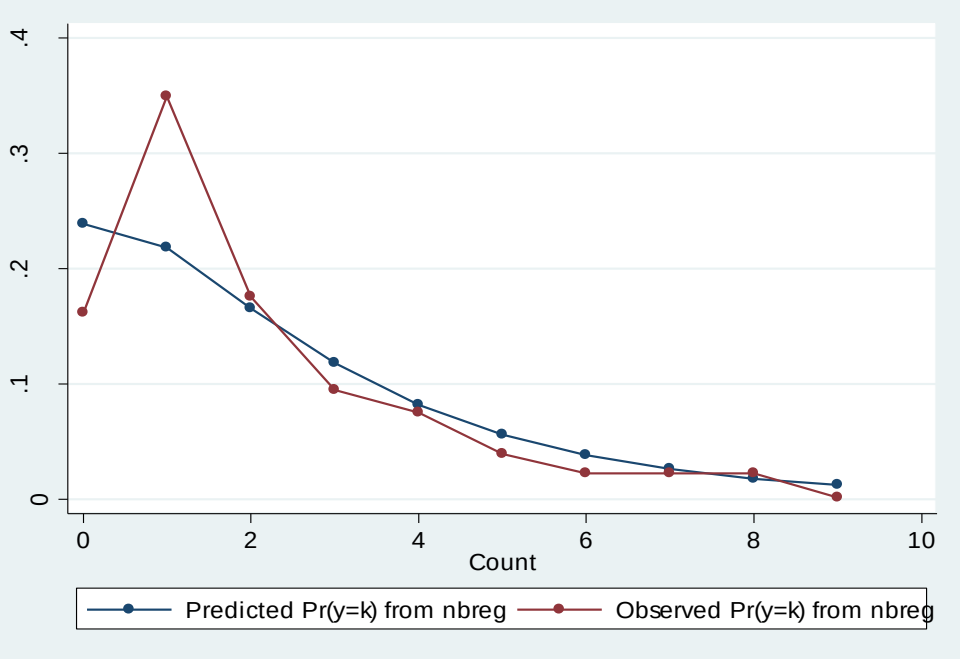
The Model prediction for Volume depletion



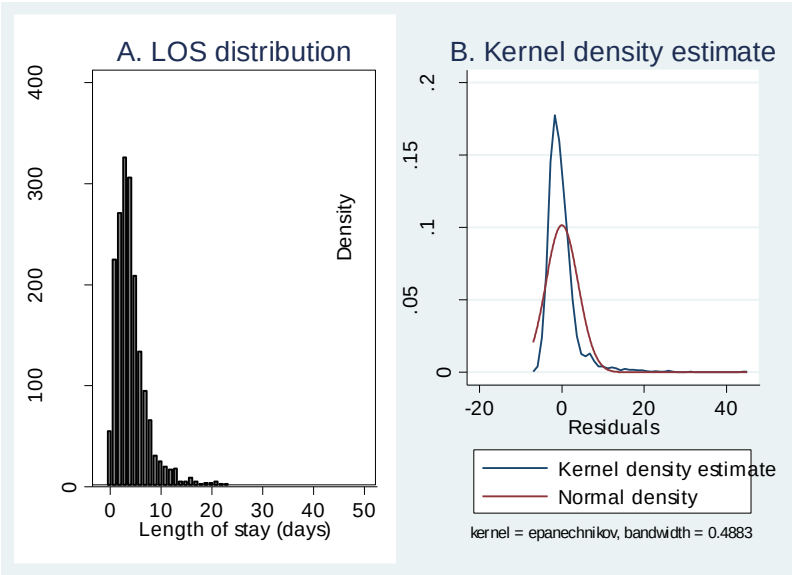
The length of hospital stay distribution and residuals normality for asthma (unspecified) diagnosis



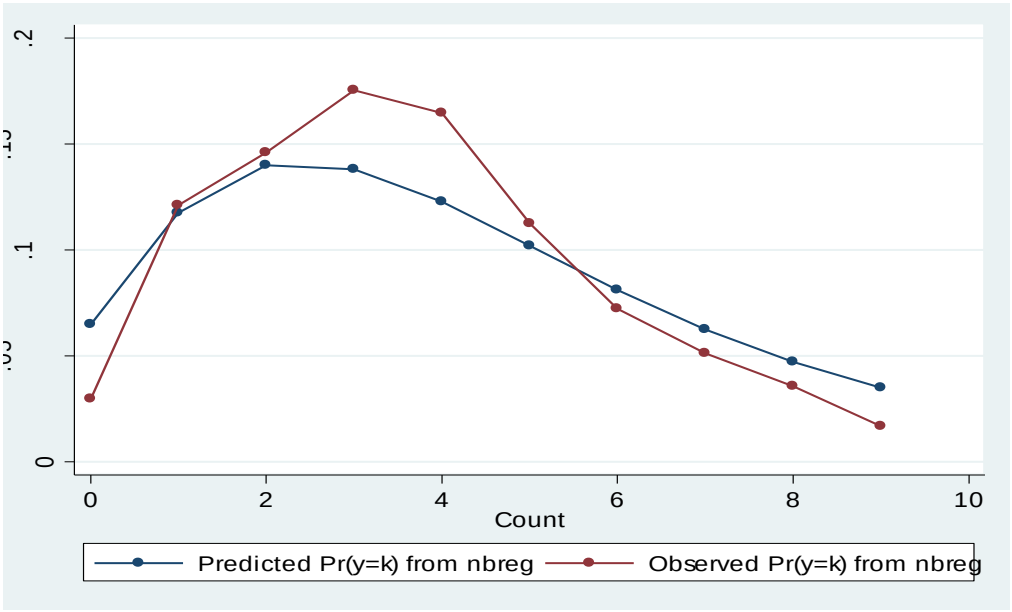
The Model prediction for the unspecified asthma



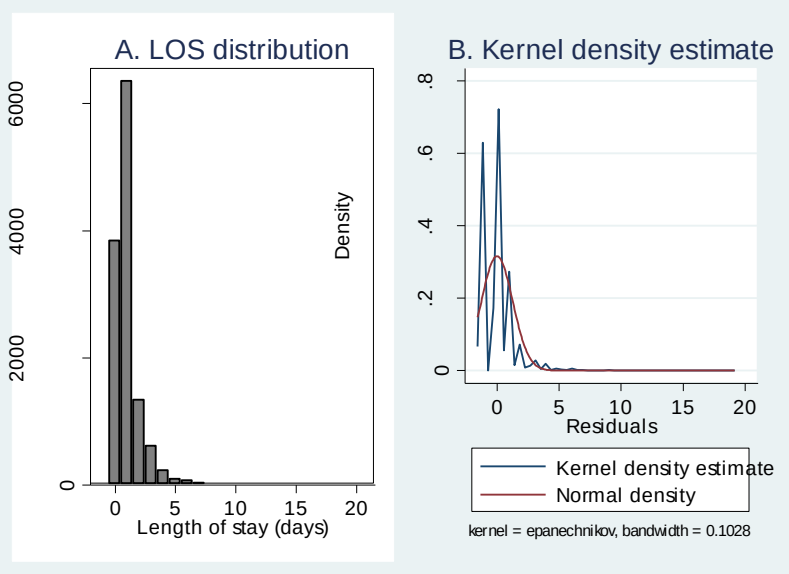
The length of hospital stay distribution and residuals normality for acute tubule-interstitial nephritis diagnosis



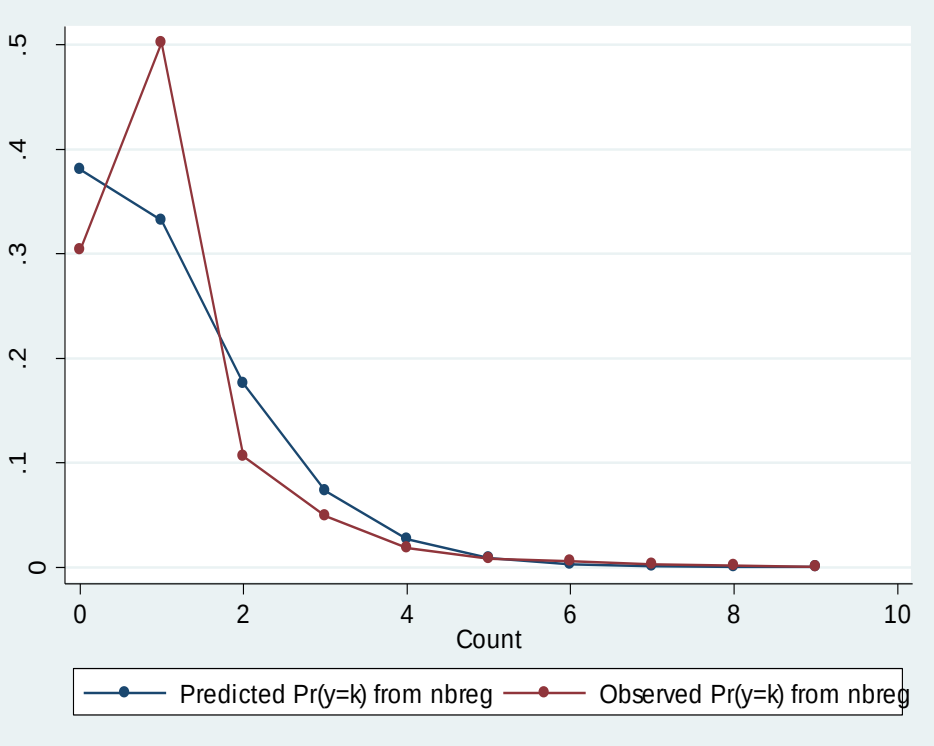
The Model prediction for acute tubulo-interstitial nephritis (N10)



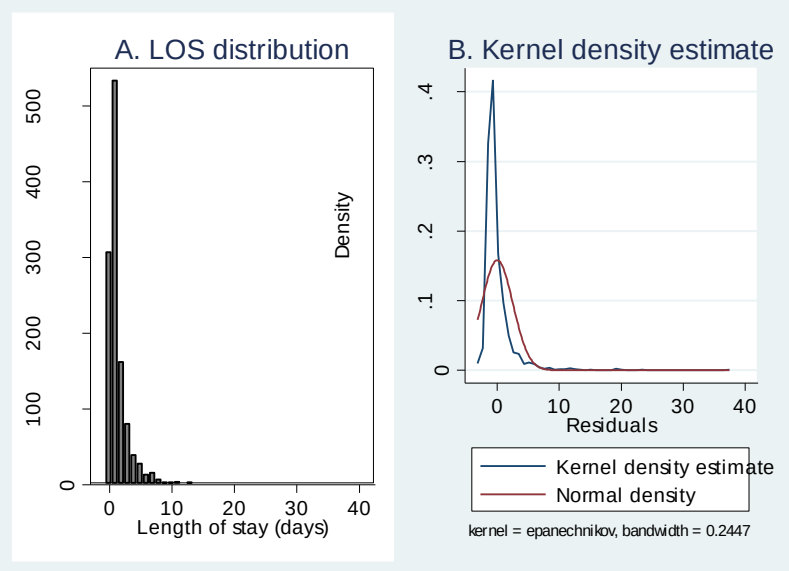
The length of hospital stay distribution and residuals normality for chest pain (unspecified) diagnosis



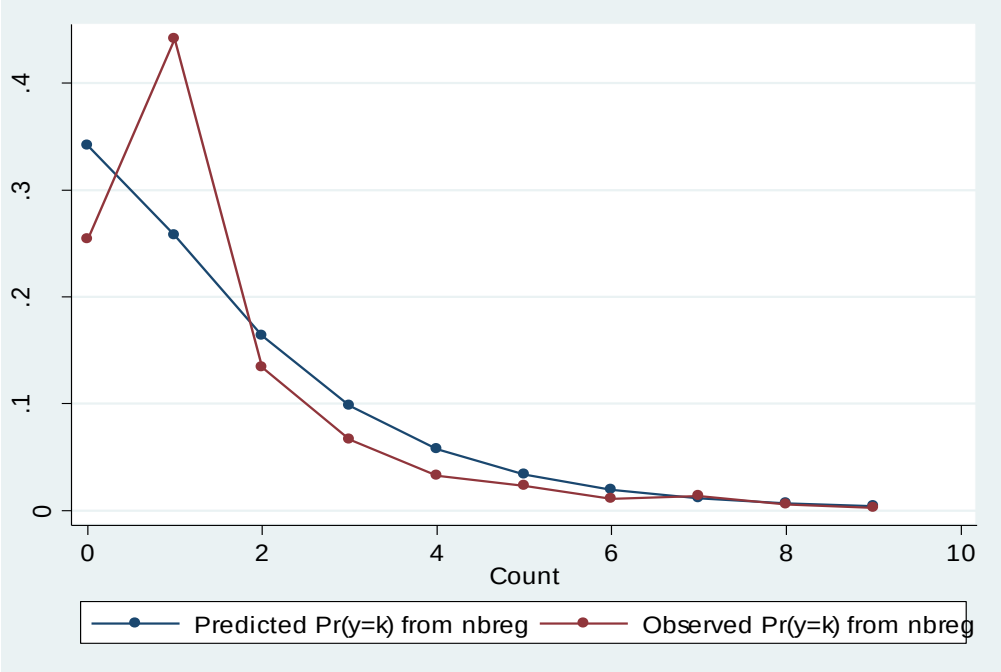
The model Prediction for the unspecified chest pain



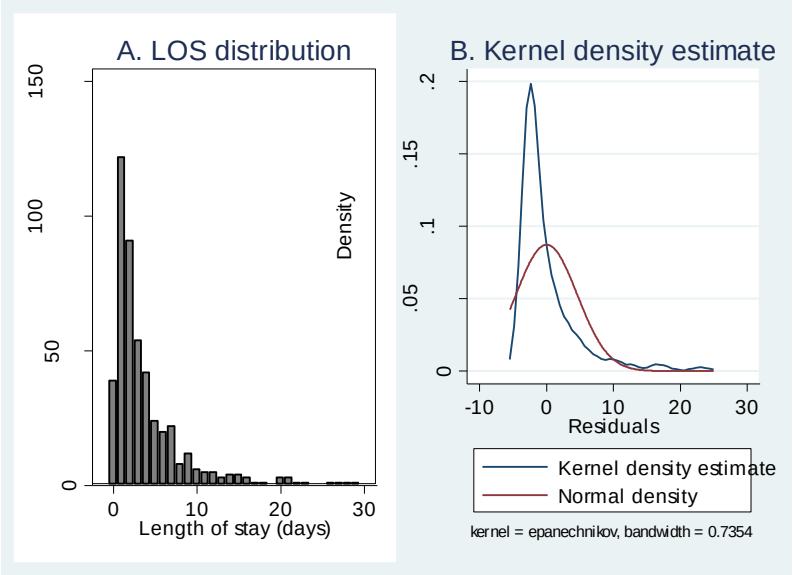
The length of hospital stay distribution and residuals normality for pain localized to upper abdomen diagnosis



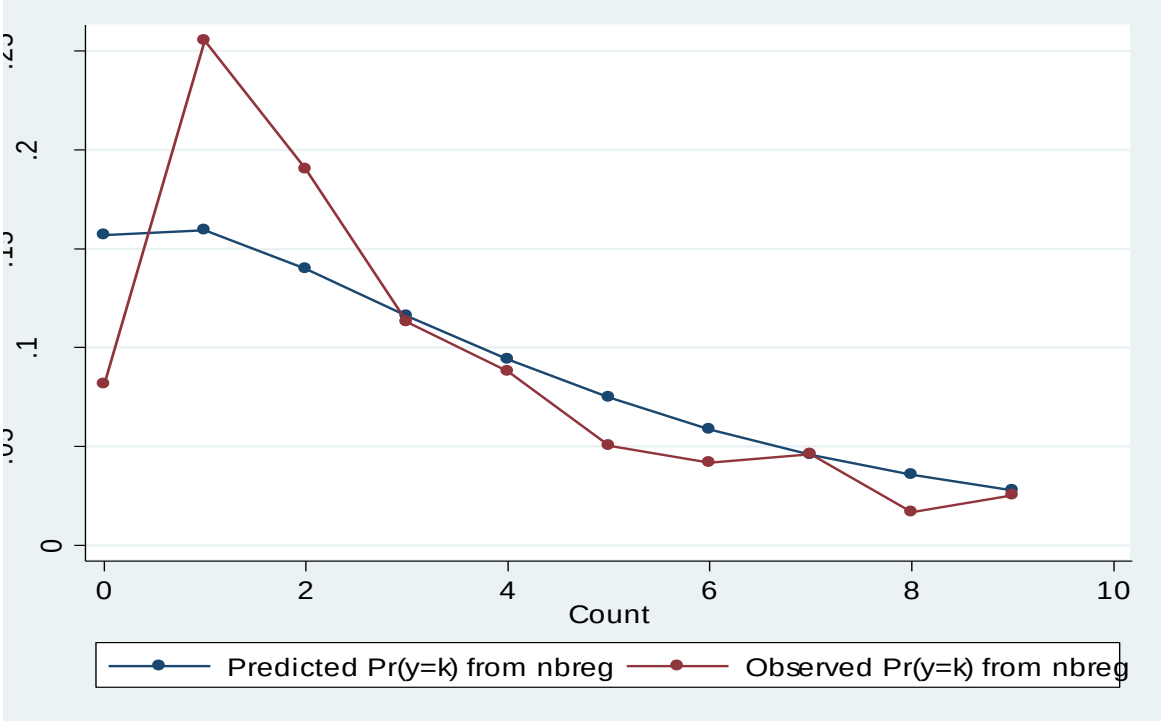
The Model prediction for pain localized to upper abdomen



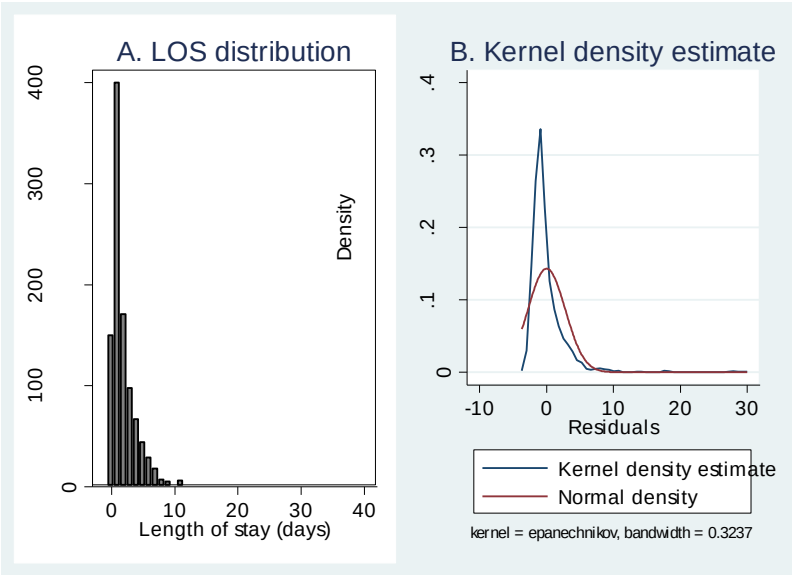
The length of hospital stay distribution and residuals normality for fever (unspecified) diagnosis



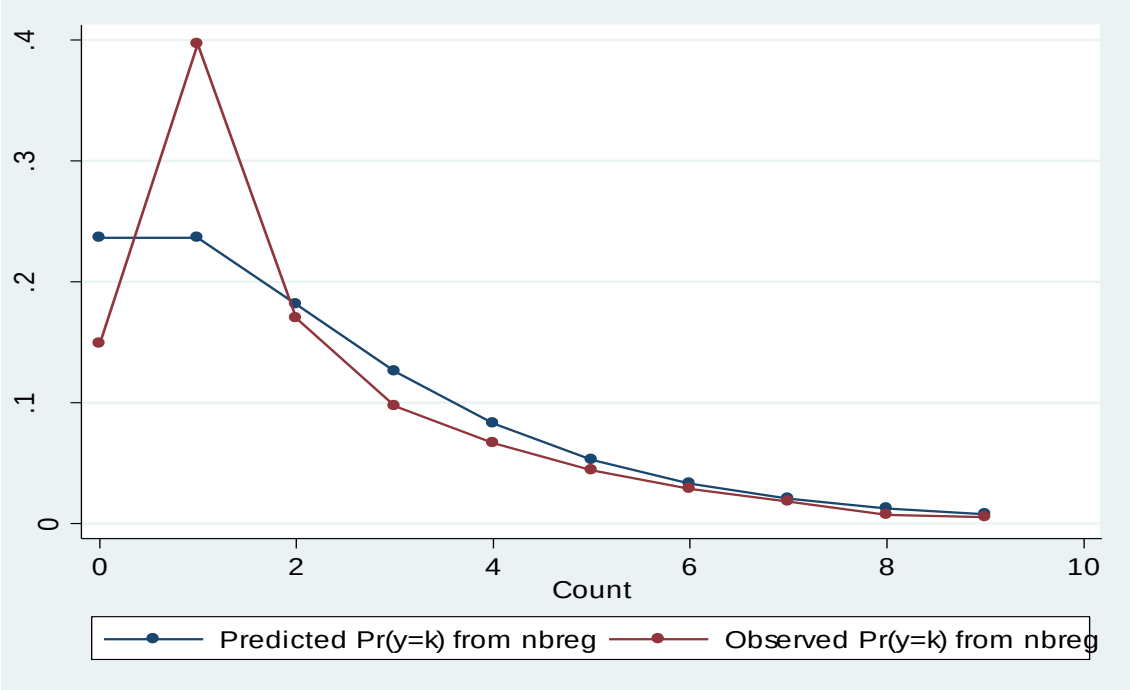
The Model prediction for unspecified Fever (R509)



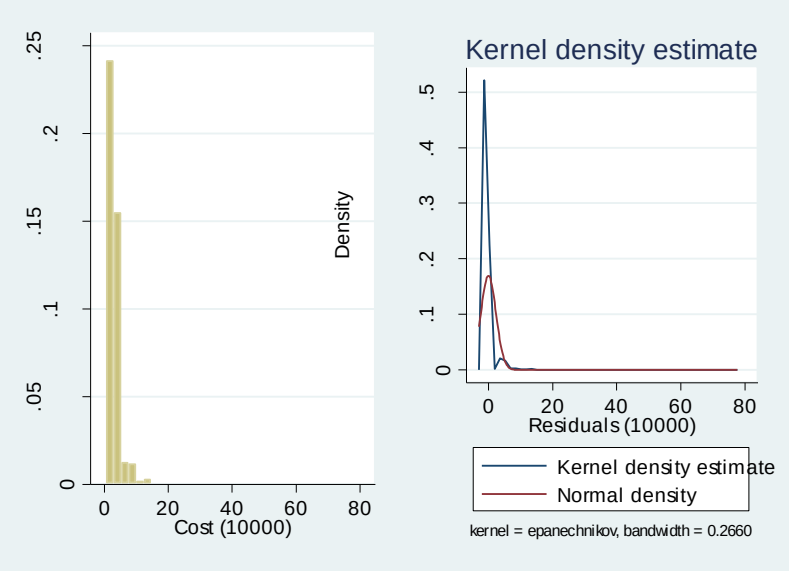
The length of hospital stay distribution and residuals normality for convulsions (unspecified) diagnosis



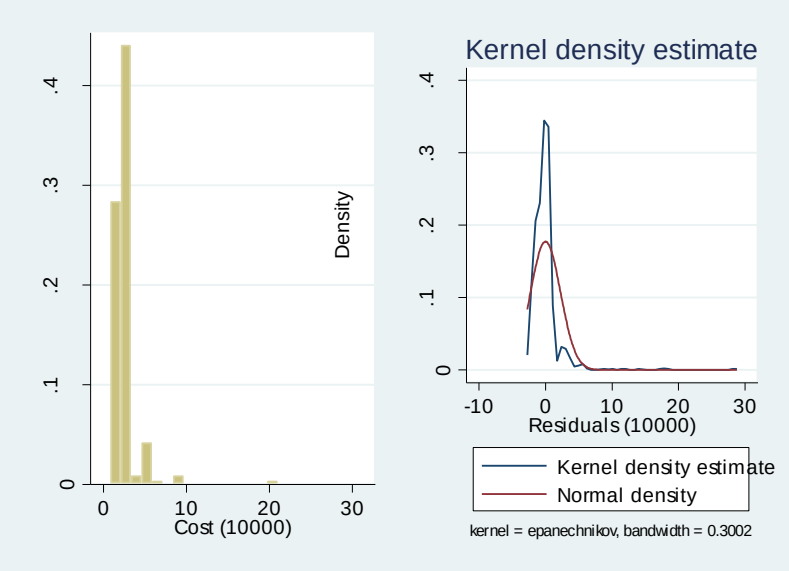
The Model prediction for unspecified convulsions (R568)



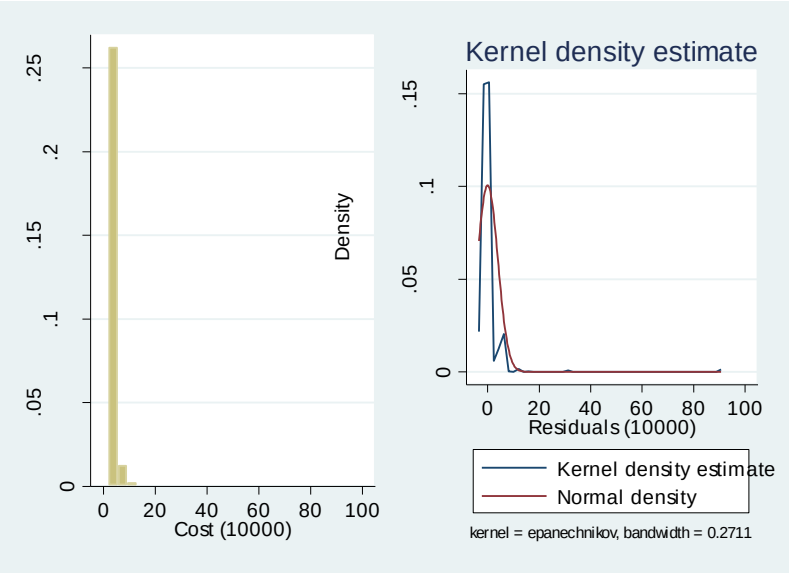
The cost distribution and residuals normality for Erysipelas diagnosis



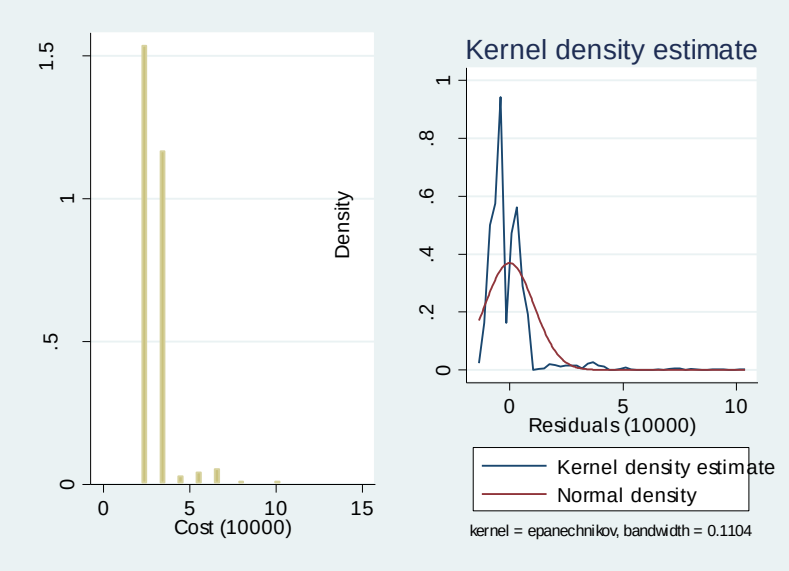
The cost distribution and residuals normality for volume depletion diagnosis



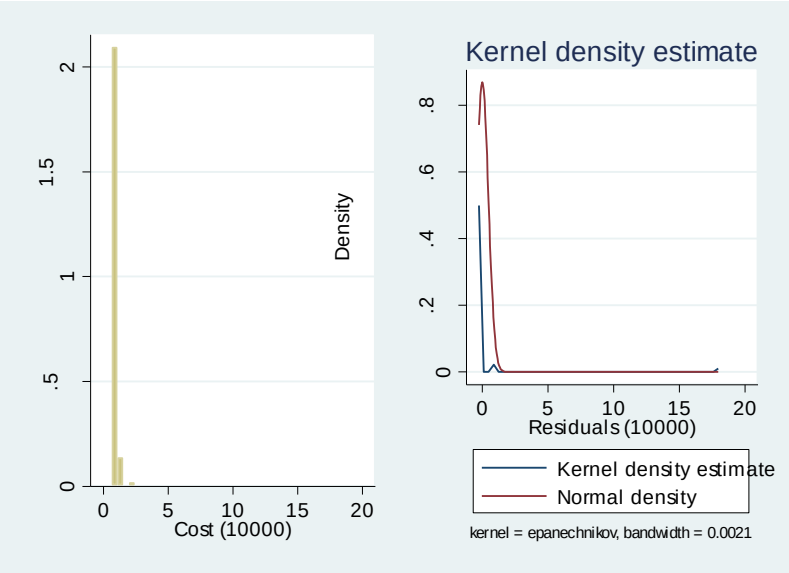
The cost distribution and residuals normality for asthma (unspecified) diagnosis



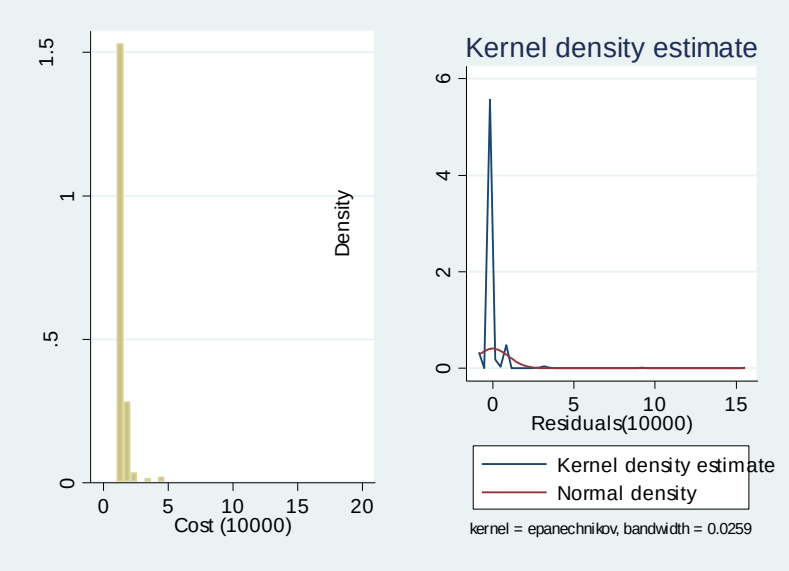
The cost distribution and residuals normality for acute tubule-interstitial nephritis diagnosis



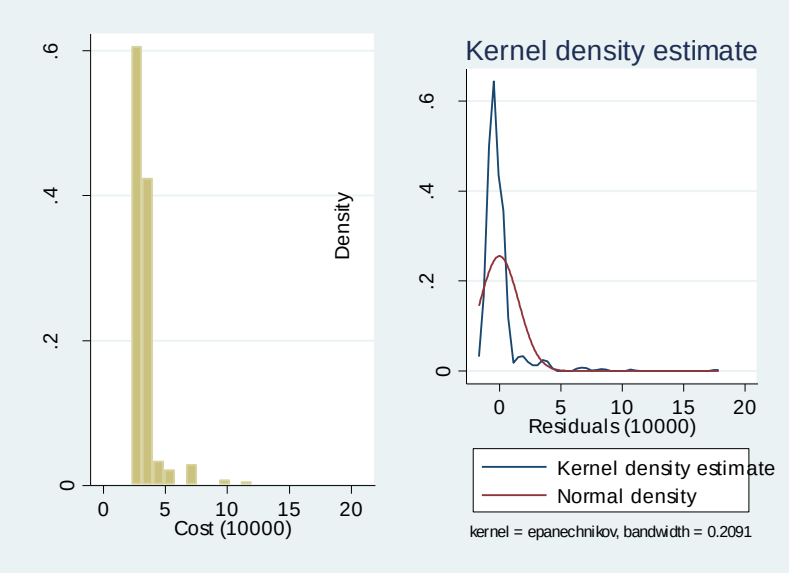
The cost distribution and residuals normality for chest pain (unspecified) diagnosis



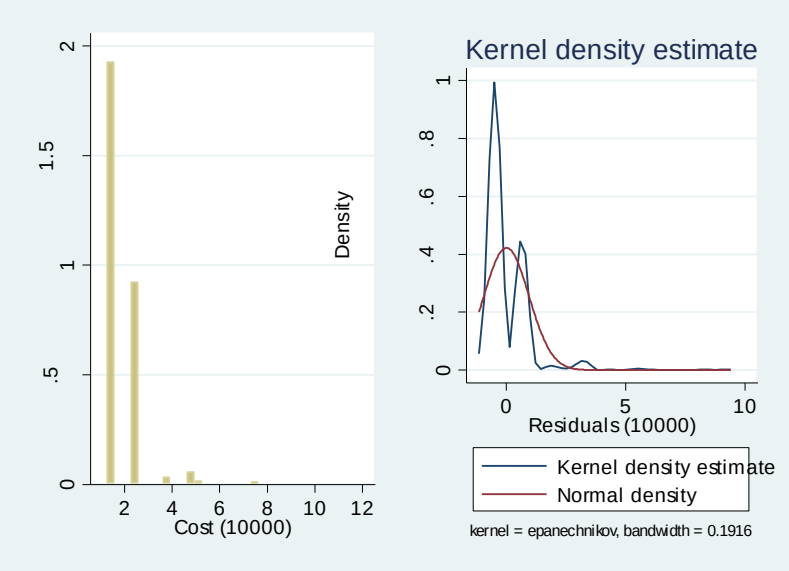
The cost distribution and residuals normality for pain localized to upper abdomen diagnosis



The cost distribution and residuals normality for fever (unspecified) diagnosis

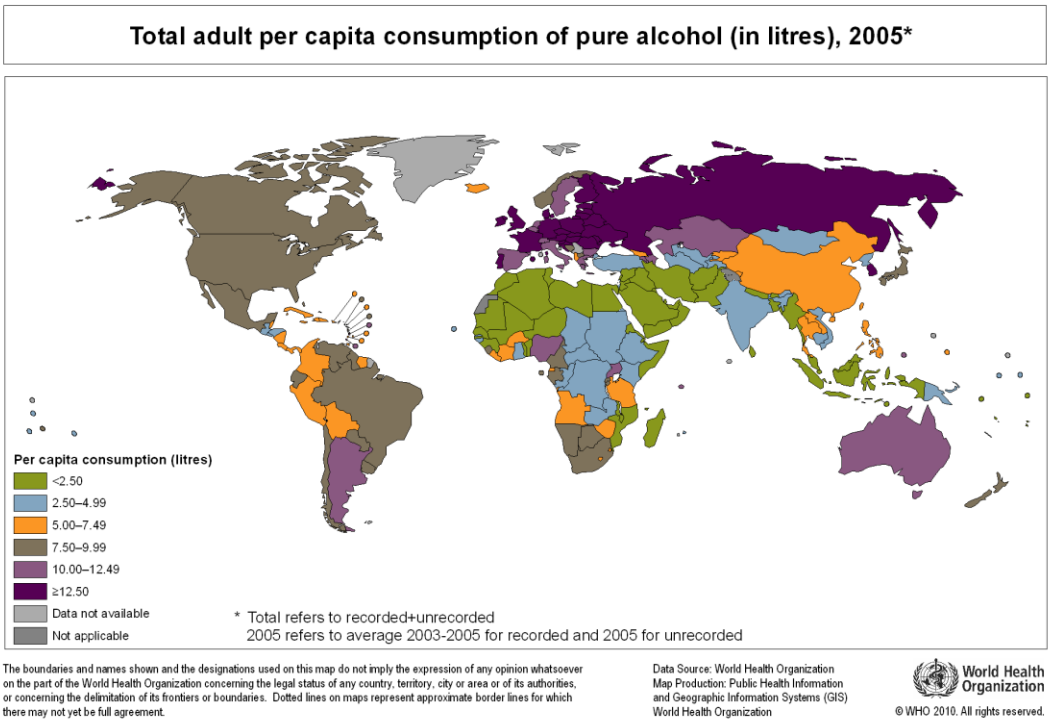


The cost distribution and residuals normality for convulsions (unspecified) diagnosis



A.VI. Total adult per capita consumption of pure alcohol

Fig7.1



Source: WHO (2011a)

A.VII. Alcohol consumption and Burden attributable to alcohol consumption

Table 8-8: Mortality, Road traffic fatalities involving alcohol

	Road traffic fatalities involving alcohol (% of all road traffic fatalities)					
Location	2007	2006	2005	2004	2003	2002
Australia		25.0	27.0	21.0		22.0
Austria	7.8	7.5	7.3	7.6	8.8	9.5
Belgium	5.6	5.0	3.5	3.0	6.0	6.7
Bulgaria	4.4	3.8	4.9	4.6	5.9	5.6
Canada	32.4	32.7	29.9	30.5	32.4	29.6
China		4.2				1.5
Cyprus	18.0	17.4	22.6	20.5	8.3	10.6
Czech Republic	3.4	4.5	5.5	4.9	8.8	11.0
Denmark	27.6	23.9	25.7	28.7	24.3	28.5
Estonia	49.5	42.2	37.7	34.7	36.6	39.0
Fiji					21.0	
Finland	24.0	26.2	23.5	22.4	17.7	21.9
France	29.4	28.9	28.8	31.4	31.7	30.3
Germany	11.4	11.8	11.3	12.1	12.4	13.6
Greece	9.2	8.0	10.7	9.4	8.2	9.1
Guam	44.0	38.5	44.0	43.0	25.0	46.0
Honduras						6.0
Hungary	13.1	13.4	12.8	14.5	11.6	13.4
Ireland			28.8	28.3	35.5	
Israel	8.6	6.9	4.6	4.9	2.3	2.1
Italy	3.7	2.8	2.1	2.7	2.2	1.7
Latvia	21.7	20.6	21.7	21.9	22.4	28.6
Lithuania	11.9	10.3	13.7	12.9	11.3	13.1
Luxembourg				14.3	3.8	9.7
Netherlands	4.0	3.0	4.8	3.6	3.1	4.7
New Zealand	27.0	24.0	25.0	27.0	27.0	24.0
Norway			22.3			
Poland	8.3	7.5	8.4	7.4	8.2	9.1
Portugal	6.7	5.3	4.7	2.5	3.2	3.0
Puerto Rico				50.0	48.0	
Republic of Korea			14.3	13.3	15.4	12.6
Romania	8.0	8.2	7.3	1.0	1.1	0.5
Slovakia	4.8	8.5	6.6	6.8	8.4	9.2
Slovenia	no data	47.7	36.8	42.3	39.7	40.9
Spain	13.9	14.2	14.4	13.9	16.1	14.9
Sweden	19.4	18.9	20.0	21.1	21.5	19.9
Switzerland	14.3	15.7	19.3	20.2	19.4	18.1
United States of America	37.9	.	.	39.5	39.9	40.7

Source: WHO (2011a)

Table 8-9: Mortality, Alcohol-related disease mortality

		Alcohol-related disease mortality, per 100,000 (15+ years)		
Location	**Time Period**	Male	Female	Both sexes
Czech Republic	2002	90.0	14.0	.
Finland	2010	.	.	29.3
	2009	.	.	30.9
	2008	.	.	30.0
	2007	.	.	30.4
	2006	.	.	27.5
	2005	.	.	28.2
	2004	.	.	23.9
	2003	.	.	19.8
	2002	.	.	31.7
France	2002	75.0	18.0	.
Germany	2010	27.9	9.3	18.4
	2009	27.0	8.8	17.7
	2008	27.7	9.3	18.3
	2007	27.7	8.9	18.1
	2006	28.7	9.5	18.9
	2005	30.3	9.7	19.8
	2004	30.4	9.6	19.8
	2003	31.6	10.1	20.6
	2002	31.8	10.1	20.7
Guam	2003	.	.	3.1
Hungary	2002	216.0	50.0	.
Iceland	2006	.	.	5.0
	2005	.	.	6.9
	2004	.	.	4.8
	2003	.	.	3.1
	2002	.	.	.
Latvia	2009	.	.	19.0
	2008	.	.	14.0
	2007	.	.	19.0
	2006	.	.	21.0
	2005	.	.	16.0
Lithuania	2002	221.0	41.0	.
Marshall Islands	2007	.	.	29.0
	2006	.	.	21.7
	2005	.	.	33.9
Mexico	2005	6.2	3.8	.
	2004	6.5	4.0	.
	2003	7.2	4.6	.
	2002	7.5	4.7	.
New Zealand	2008	5.2	1.9	3.5

	2007	4.2	1.5	2.9
	2006	5.0	1.8	3.5
Norway	2007	10.8	3.4	5.9
	2006	10.7	3.3	9.0
	2005	11.4	3.1	7.9
	2004	14.9	3.7	8.3
	2003	13.6	4.2	11.3
	2002	14.2	3.8	10.9
Poland	2002	87.0	9.0	.
Russian Federation	2002	290.0	47.0	.
Slovenia	2007	118.2	35.9	76.5
Sweden	2007	.	.	10.9
	2006	.	.	10.4
	2005	.	.	10.9
	2004	.	.	11.5
	2003	.	.	11.2
	2002	27.0	5.0	14.1
Ukraine	2004	281.5	72.2	167.4
United Kingdom	2009	17.4	8.4	12.8
	2008	18.7	8.7	13.6
	2006		14.8	
	2003	.	.	11.6
	2002	37.0	13.0	.

Source: ***WHO (2011a)***

Table 8-10: Alcohol harms and consequences in Norway, in 2004

Harm	DALYs[2] per 100,000			Mortality[3] per 100,000		
	Male	**Female**	**Both**	**Male**	**Female**	**Both**
Alcohol use disorder	1497	425	**969**	5.3	0.8	2.9
Breast cancer	1	301	152	0,1	20	10.7
Cerebrovascular disease	316	253	**283**	41,5	34	**37.3**
Colon and rectum cancers	210	158	183	25.6	17.5	21
Diabetes mellitus	178	173	175	8.7	5.4	6.9
Drownings	57	24	40	2.6	0.9	1.7
Falls	202	111	157	9	5.8	7.2
Fires	34	15	25	1,3	0,7	1
Ischaemic heart disease	725	254	**482**	103	48.3	**72.7**
Liver cancer	15	9.4	12.2	2	1.4	1.7
Liver cirrhosis	93	37	65	6.5	0.1	4.3
Mouth and oropharynx cancer	29	9	19	3.1	0.1	2
Oesophagus cancer	36	12	24	4.6	0.1	2,9
Poisoning	289	102	197	11.4	0.1	8
Prematurity and low birth rate	26	29	28	0.2	0	0.3
Road traffic accidents	332	118	227	8.9	0.1	5.8
Self-inflicted injury	348	162	**256**	14.7	0.2	10.7
Other unintentional injuries	338	181	**261**	9.6	3.8	6.6
Violence	41	20	31	1,1	0	0,8

Source: WHO (2011a)

[2] Age-standardized disability-adjusted life years
[3] Age-standardized death rates

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